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LOCALIZED FIBROUS MESOTHELIOMA OF THE PLEURA

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DURING the past decade we have become increasingly conscious of a small group of circumscribed tumors situated in the thorax. They often are intimately associated with the pleura, but less commonly occur in the periphery of the lung and occasionally in the mediastinum. This group of tumors has not readily fallen into the more commonly accepted classification of intrathoracic tumors. It became apparent after studying these tumors that they are tumors sui generis, which because of their peculiar clinical course are of particular interest to the thoracic surgeon.

Klemperer and Rabin[1] said, "Although primary pleural neoplasms are classed among the rarer types of tumors, their importance has been recognized in a rather extensive literature." According to Saccone and Coblenz[2] (1943), more than 200 authors had discussed and offered opinions regarding these tumors and had described the perplexities of their clinical, roentgenologic and pathologic features. Some evidence of the confusion that occurred in the literature is Krumbein's[3] finding that thirty different names had been used to describe these tumors. In more recent years, some order has come out of the chaos that has existed. Notable contributions toward clarification have been made by Klemperer and Rabin[1] and by Stout and Murray.[4] It now seems reasonable to divide tumors arising from the pleura into two distinct groups. The first but less common group consists of localized tumors resembling fibromas or fibrosarcomas, and the second group includes tumors of a diffuse nature involving the entire pleura, both parietal and visceral. Our experience is in

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general agreement with that of Klemperer and Rabin who said, "Localized tumors may involve the parietal or visceral pleura. They comprise many histologic types and benign and malignant forms. The entire group is possessed of a common characteristic. They originate from the tissue beneath the superficial lining cells of the pleura in contradistinction to the diffuse form of pleural tumors which arise from the surface lining." These two groups of tumors are entirely different as regards their gross and microscopic characteristics, their clinical manifestations and course, and their treatment and prognosis. Much of the confusion that has existed is due to the fact that these 2 groups of tumors of pleural origin have been considered as a single entity in much of the literature whereas they actually have nothing in common except their supposed origin in the pleura. As a result of our experience with localized fibrous mesotheliomas of the pleura, we believe that these tumors constitute a definite disease entity both pathologically and clinically.

It has been difficult to select a proper name for the group of tumors from the thirty terms that have been applied in the past. Since both localized and diffuse pleural tumors have a mesothelial origin, and since the term "mesothelioma" recently has gained acceptance, it seems wise to accept this term. However, in order to distinguish these groups of tumors sharply we shall name the tumors under discussion "localized fibrous mesotheliomas," and the other group, "diffuse malignant mesotheliomas."

There are no accurate figures in the literature to indicate the true incidence of localized fibrous mesotheliomas. According to Ramström and Hellsten,[5] Lichenstem[6] was able to collect reports of only 8 cases of tumors of this type from medical literature up to 1931. These authors found reports of 3 more cases in the literature between 1931 and 1951, and added reports of 3 new cases, making a total of only 14 cases reported up until 1951. Undoubtedly reports of many cases were overlooked in the confused literature on this subject, however, because we have been able to collect a series of 24 cases of tumors of this type in which operation was performed at the Mayo Clinic. There were 14 males and 10 females in our series, a slightly different ratio from the 2:1 ratio mentioned in some of the reports in the literature. The age of the patients in our series ranged from 21 to 70 years, and the average age was 49.3 years.

The association of pathologic changes in bones and joints with intrathoracic tumors and diseases has been noted frequently since it was described independently by Bamberger[7] and Marie[8] in 1890. Van Hazel[9] presented a paper on this subject before the American Association for Thoracic Surgery in 1939 and reported a series of 7 cases of tumor of the lung in which the initial symptoms had been changes in the joints. In 5 of the 7 cases, the tumor was malignant; in the 2 remaining cases, it was benign. Although articular manifestations do occur in some cases of bronchogenic carcinoma, they are not very common. In a series of more than 200 cases of carcinoma of the lung reviewed recently, we found only 4 in which there were any symptoms ref-

erable to joints. It was therefore of considerable interest to note that in 16 of the 24 cases of localized fibrous mesothelioma of the pleura there were symptoms or physical findings, or both, referable to joints. In many of the cases, these symptoms were primarily responsible for bringing the patients to a physician. Articular symptoms had been present for from four months to sixteen years. In 9 cases, these symptoms had been present for more than one year. The most frequent sites of articular involvement in order of decreasing frequency were the hands, ankles, shoulders, wrists, elbows, and knees. In some cases, the patients were almost entirely disabled by the articular manifestations. When the articular reactions were of short duration and unaccompanied by clubbing of fingers and toes, it was impossible even for rheumatologists to distinguish clinically the arthritis from rheumatoid arthritis occurring in patients without thoracic tumors. Clubbing of the finger tips or toes or both (Fig. 1), sufficient to attract the attention of the physician, occurred in eleven cases, and minor degrees of clubbing may well have been overlooked in some patients who were seen before we became fully aware of the frequent association of this finding with pleural lesions of this type. In 7

Fig. 1.—Typical clubbing of finger tips in case of fibrous mesothelioma of the pleura.

cases, there was a history of recurrent attacks of chills or chilly sensations and fever of unknown cause having occurred before the intrathoracic lesion was discovered. Fever was found generally to occur only in patients with symptoms referable to their swollen painful joints. It would appear that chills and fever may well be considered a part of the clinical picture in some cases of localized fibrous tumors arising from the pleura.

Some of the patients with large tumors complained of dyspnea but it was not often a prominent symptom. Loss of weight was rarely observed. Thoracic pain did not occur in any case. In a number of cases, the patients were entirely free of symptoms and the intrathoracic lesions were discovered as incidental findings in routine thoracic roentgenograms.

The physical findings other than clubbing of the fingers and swollen painful joints were those that would be expected in any case of intrathoracic tumor of similar size. No abnormal physical findings were noted in cases in which the tumors were small.

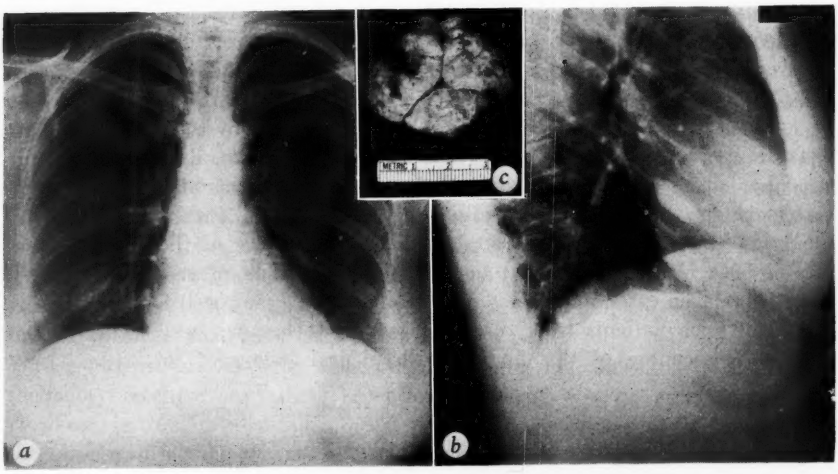

Fig. 2.—*a*, Anteroposterior roentgenogram showing area of increased density in lower portion of right lung; *b*, lateral roentgenogram showing an ovoid interlobar tumor; *c*, fibrous mesothelioma of pleura responsible for roentgenographic changes shown in *a* and *b*.

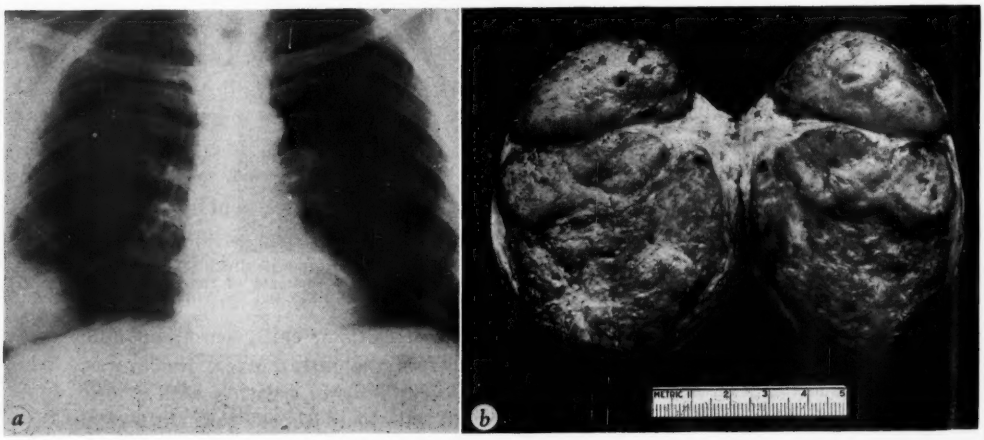

Fig. 3.—*a*, Anteroposterior roentgenogram showing rounded shadow of increased density in lower part of right side of thorax; *b*, fibrous mesothelioma of pleura responsible for roentgenographic changes in *a*.

DIAGNOSIS

It must be admitted that a definite diagnosis of fibrous pleural tumor was not made preoperatively in any of the cases in this series. However, the possible presence of this lesion was considered in a few cases. In most cases exploratory

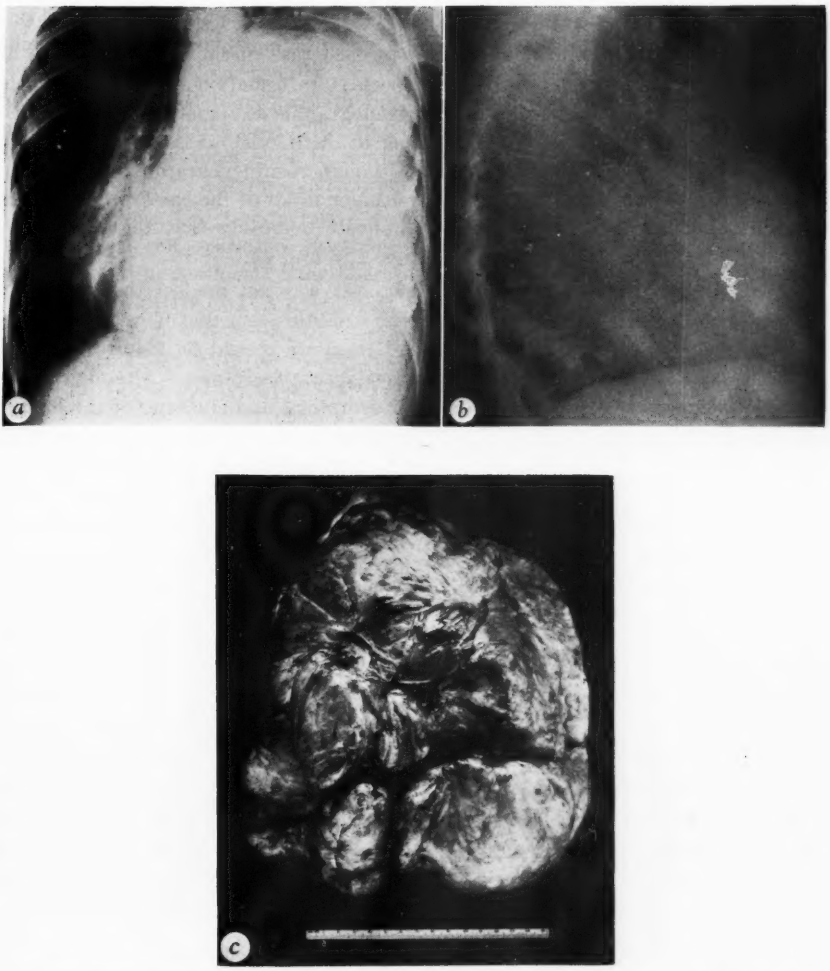

Fig. 4.—*a*, Anteroposterior roentgenogram showing shadow of huge tumor filling the left side of the thorax and causing deviation of the mediastinum to the right. Some calcification is evident in the periphery of the tumor; *b*, lateral roentgenogram showing huge lobulated tumor filling the left side of the thorax; *c*, mesothelioma of the pleura responsible for the roentgenographic changes shown in *a* and *b*. The tumor weighed 3,480 grams.

thoracotomy was advised because of a preoperative diagnosis of indeterminate intrathoracic tumor. Bronchoscopy was performed in a few instances but, as would be expected considering the pleural origin of these tumors, it did not contribute anything to the diagnosis except to exclude the presence of a lesion in the major bronchi.

Thorough roentgenographic studies in each case disclosed the presence of an intrathoracic lesion and provided important information regarding the site and size of the tumor. However, roentgenographic examination did not disclose any features that would permit one to distinguish these tumors from a variety of other intrathoracic tumors. Although roentgenographic examination disclosed the presence of an intrathoracic tumor in all of the cases in this series, the roentgenographic findings did not indicate definitely that the tumor was of pleural origin in any of the cases (Figs. 2, 3 and 4).

Although a correct preoperative diagnosis was not made either clinically or roentgenologically in this series of cases, it would seem that if we profit from the knowledge gained from our review of them we should be able to diagnose at least some of these tumors preoperatively in the future. Although other intrathoracic lesions can produce articular symptoms and clubbing of the fingers in some cases, we know of no other intrathoracic tumor in which a clinical history of chills, fever, migratory swelling and pain in the joints, and clubbing of fingers occur so commonly. A clinical history of this type obtained in a case of circumscribed intrathoracic tumor should make one consider the possibility of localized fibrous mesothelioma.

SURGICAL CONSIDERATION

The tumors removed at operation varied in size from 4 cm. to 36 cm. in diameter and from 50 to 5,000 grams in weight. In many cases in which the tumors were large, it was impossible to determine the exact site of origin of the tumor. As accurately as could be determined, the tumor arose from visceral pleura in 18 cases and from parietal pleura in 6 cases. Thirteen of the tumors arising in the visceral pleura were situated in the right side of the thorax and five in the left. Two tumors which originated in the parietal pleura were situated extrapleurally, two apparently arose from the mediastinal pleura, and two arose from the pleura of the lateral wall of the thorax but were situated intrapleurally. Grossly and microscopically, all of these tumors, regardless of their situation or site of origin, seemed identical.

It should be noted that pleural effusion was present in 4 of the 24 cases. In 3 of these cases, the presence of pleural effusion was established preoperatively by thoracentesis; in the fourth case, a few hundred cubic centimeters of clear fluid that had not been suspected preoperatively were found at operation. In one instance, bloody pleural fluid was aspirated on several occasions preoperatively. In all cases in which pleural effusion was found, the tumor was removed successfully. Hawthorne and Frobese[10] have reported removal of a fibrous pleural tumor which was associated with a pleural effusion.

In 18 cases, the tumors were removed by excision without pulmonary resection. Some of the smaller tumors were attached to the lung by a small vascular pedicle (Fig. 5), and only a ligature or a few sutures were necessary to accomplish complete removal of the tumor and repair of the lung from which the tumor had originated. Large tumors often were attached to the lung and thoracic wall by vascular adhesions. However, except in the cases of very large tumors, the operations usually were not difficult. One or more lobes of the lung were removed together with the tumor in 6 cases. Pneumonectomy was performed in only one case. The tumor, in that case, was embedded in the fissures between the lobes close to the hilus of the lung. Since biopsy indicated that the tumor was a fibrosarcoma, pneumonectomy seemed indicated.

There were two postoperative deaths in this series of 24 cases. One occurred the day of operation which had included removal of the tumor together with the left upper lobe. This operation was performed in 1931, long before thoracic operations of this magnitude were commonly performed. The result in this case is not very surprising. The other death occurred one week after operation. There were no major postoperative surgical complications in this case, the patient dying of hypertensive heart failure.

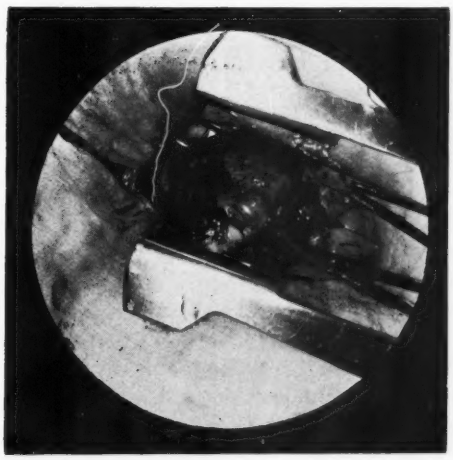

Fig. 5.—Fibrous mesothelioma of the pleura attached to lung by a pedicle.

As accurately as we can determine from our follow-up investigations, there has been local recurrence of the tumor in 4 cases, and, so far as we can determine, with one possible exception, none of the tumors has metastasized to other parts of the body. In 2 cases, the tumor recurred within six months. These two recurrent tumors were treated with deep roentgen therapy, but the patients died within two years. In the third case, the tumor recurred after eight years, and the patient died two years later. In the fourth case, the recurrent tumor was noted four years after operation, and the patient died a year later.

One patient who was 70 years old at the time of operation died one year later. We have not been able to learn the cause of this patient's death. All of the other patients were well and free of symptoms at the time of a recent follow-up study.

Fig. 6.—Section of fibrous mesothelioma of pleura showing variation in cellular pattern. Some areas are relatively acellular and contain dense bundles of collagen while others are very cellular. (Hematoxylin and eosin stain; ×50.)

GROSS FEATURES

In all of the cases in this series the tumors were encapsulated. In the majority of cases, gross examination revealed definite lobulation which was particularly prominent on the surface of the tumor. Bosses were present on the surface of the tumor. On section, some of the tumors had an appearance which suggested placental tissue, and cystic formation occasionally was evident. Calcium was present in one tumor (Case 21); necrosis and hemorrhage were present in only one case (Case 22). The latter was the only case in which histologic examination disclosed undeniable evidence of malignancy. The weight of the tumors varied greatly (Table I). Three of these tumors were very large and weighed from 8 to 10 pounds (3.6 to 4.5 kg.). The site of the tumor in the thorax varied. In 13 of the 24 cases the tumor was pedunculated; it was attached to either the visceral or parietal pleura and projected into the pleural cavity. Pleural fluid was present in 4 of the 13 cases. Six of the tumors were embedded in the lung close to the visceral pleura. Other tumors appeared to arise primarily as mediastinal enlargements. A few were attached to the pleura with a broad pedicle and projected a short distance into the pleural cavity.

HISTOLOGIC FEATURES

All of the tumors were composed of spindle cells which produced collagen intercellularly. Some portions of the tumors were relatively acellular, and the cells that were present in these portions were slender spindle cells. A comparatively large number of spindle cells were present in other portions of

the tumors, and mitotic figures occasionally could be seen (Fig. 6). In these relatively cellular portions, the spindle cells were more plump than those in the relatively acellular portions. In the latter portions, fingerlike projections of dense bundles of collagen were arranged in an interlacing manner. In the relatively cellular portions, the collagen was much finer and frequently appeared only as precollagen in sections which were stained with Gömöri's reticulum stain. These fingerlike projections of bundles of collagen were a prominent feature of the tumors in this series of cases (Fig. 7). They probably account for the fact that a fibrous mesothelioma occasionally has been mistaken for a neurofibroma. These projections, however, are not a prominent feature of fibromas.

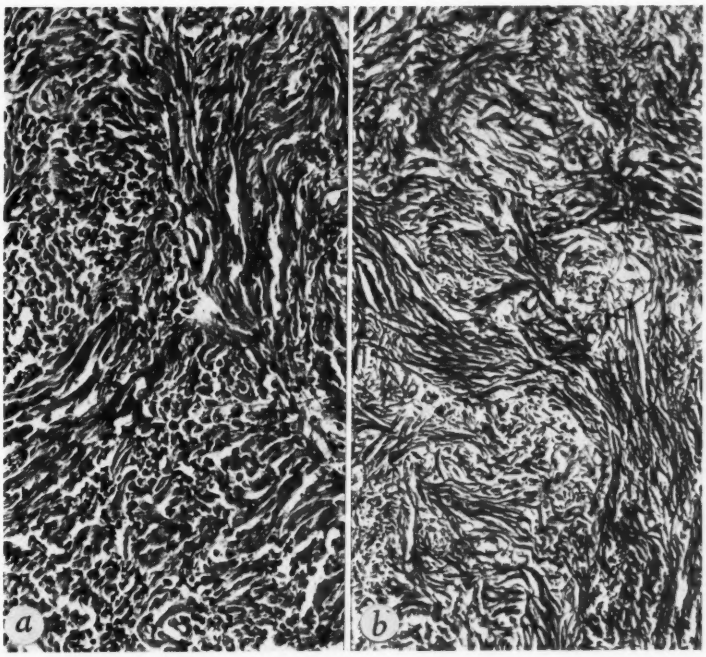

Fig. 7.—Sections of relatively acellular portion of fibrous mesothelioma of pleura showing dense bundles of collagen: *a*, section stained with hematoxylin and eosin (×145); *b*, section showing interlacing of bundles of collagen (Gömöri's reticulum stain, ×200).

Mitotic figures were found in a small proportion of the tumors in this series of cases. They usually were situated in portions of the tumor which contained a relatively large number of cells. A large number of these figures were present in only 1 case (Case 22). In this case, the cells and nuclei were large and irregular, the latter were hyperchromatic, and the histologic picture of the entire tumor resembled that of a malignant tumor (Fig. 8). The clinical course also suggested that the tumor was malignant, because it recurred locally a short time after its removal but definite evidence of metastasis was lacking.

TABLE I. CLINICAL DATA IN 24 CASES OF LOCALIZED FIBROUS MESOTHELIOMA OF THE PLEURA

CASE	AGE (YEARS)	SEX	ARTICULAR PAIN AND SWELLING	DURATION OF ARTICULAR SYMPTOMS	CLUBBING OF FINGERS	KNOWN DURATION OF THORACIC LESION	WEIGHT OR DIAMETER OF THORACIC LESION	ORIGIN OF TUMOR	OPERATION	RESULT
1	32	F	+	9 mo.		9 mo.	130 Gm.	Visceral pleura of middle lobe	Local excision	Well, Feb., 1952
2	49	F	+	9 mo.		9 mo.	9 Gm.	Visceral pleura of lower lobe	Local excision	Well, Jan., 1952
3	53	F				3 yr.	165 Gm.	Parietal pleura	Local excision	Well, Feb., 1952
4	40	M	+	6 mo.			4 cm.	Visceral pleura of right lower lobe	Local excision	Well, Jan., 1952
5	31	F	+	15 yr.		4 yr.	180 Gm.	Parietal pleura (extrapleural)	Local excision	Recurrent tumor excised six mo. later; death 2 yr. after excision of primary tumor
6	47	F	+	16 yr.	+	1 wk.	3,480 Gm.	Visceral pleura of left lower lobe	Local excision	Well, Jan., 1952
7	36	M	+	4 yr.	+	5 yr.	4,050 Gm.	Visceral pleura of middle and lower lobes right lung	Removal of middle and lower lobes of right lung	Well, Jan., 1952
8	54	M				2 mo.	75 Gm.	Visceral pleura of right lower lobe	Local excision	Well, Jan., 1952
9	48	M	+	4 mo.	+		220 Gm.	Visceral pleura of left lower lobe	Local excision	Well, Jan., 1952
10	61	F	+	6 mo.	+	2 wk.	860 Gm.	Visceral pleura of right upper lobe	Local excision	Well, Jan., 1952
11	58	M	+	28 yr.*	+		140 Gm.	Visceral pleura of right middle lobe	Local excision	Well, Jan., 1952
12	44	M	+	1 yr.	+		4,972 Gm.	Visceral pleura of right lower lobe	Local excision	Recurrence; death 5 yr. after operation
13	59	F	+	4 yr.	+		2,865 Gm.	Visceral pleura of right lower lobe	Local excision	Well, Jan., 1952
14	55	M	+	15 yr.			180 Gm.	Mediastinum	Local excision	Well, 1 yr. after operation
15	21	F				6 mo.	5.5 cm.	Beneath visceral pleura	Pneumonectomy	Well, Jan., 1952

16	64	M					40 Gm.	Beneath visceral pleura	Removal of middle and lower lobes of right lung	Died of hypertensive heart failure, 1 wk. after operation
17	53	M				8 yr.	20 Gm.	Visceral pleura of middle lobe	Local excision	Well, Oct., 1951
18	52	M	+	3 yr.	+		1,260 Gm.	Visceral pleura of left upper lobe	Removal of left upper lobe	Postoperative shock; death on day of operation
19	50	M					170 Gm.	Parietal pleura on left side (extrapleural); erosion of tenth rib	Local excision	No recurrence for 3 yr.
20	41	M				2 mo.	3.5 cm.	Fissure between middle and upper lobes right lung	Removal of upper and middle lobes of right lung	Well, Jan., 1952
21	70	F					1,300 Gm.	Parietal pleura (mediastinal)	Local excision	Well at end of 1 yr., but died subsequently of unknown cause
22	56	M	+	6 mo.	+	2 wk.	6 cm.	Visceral pleura of right lower lobe	Removal of right lower lobe	Recurrence in 6 mo.; death 1 yr. after operation
23	45	M	+	1 yr.	+	1 yr.	825 Gm.	Parietal pleura (extrapleural)	Local excision	Recurrence 8 yr. after operation; death 10 yr. after operation
24	65	F	+	4 mo.	+		115 Gm.	Visceral pleura of upper and lower lobes	Local excision	Well, Jan., 1952

*This patient had gout as well as pleural mesothelioma. Impossible to determine exact duration of any joint symptoms referable to pleural tumor.

In 1 case (Case 5), the clinical course did suggest the presence of embolic metastasis. In this case, a recurrent tumor was removed, and the patient died two years after removal of the primary tumor. At the time of the patient's death, multiple nodules were present beneath the skin. The histologic nature of these nodules was not determined. The histologic appearance of the tumor in this case did not differ from that of the tumors which followed a benign course clinically.

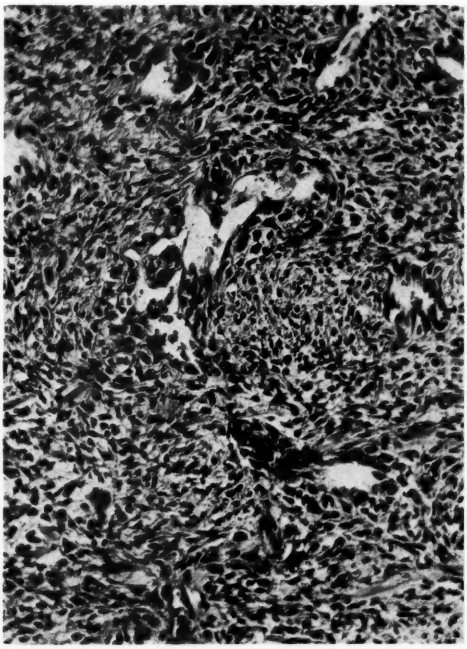

Fig. 8.—Fibrous mesothelioma of pleura showing evidence of malignancy (hematoxylin and eosin stain, ×180).

Necropsy was performed in 2 cases (Cases 16 and 18). In both of these cases, the necropsy was performed shortly after removal of the respective tumors. In neither case was any residual tumor found, nor was there any evidence of metastasis. Another almost constant finding in these 24 cases was the presence of spaces lined by spindle cells (Fig. 9). In 1 case (Case 20), these spaces were lined by columnar cells and had the appearance of actual glands. A number of these spaces contained coagulated proteinlike material which resembled secretion. The collagen bundles and cells appeared to be avoiding these spaces. Whether these spaces are true glands or attempts at the formation of coelmic spaces is conjectural. Mucoid degeneration was a feature of some of these tumors. It was, however, never as marked as one sometimes sees in fibrogenic tumors of the extremities.

COMMENT

We believe that our experience with this series of cases of localized fibrous mesothelioma should establish the fact that this tumor is a distinct pathologic and clinical entity which should be sharply distinguished from a diffuse malignant mesothelioma of pleural origin. Localized fibrous mesotheliomas of the pleura are of importance to the thoracic surgeon because these tumors are resectable. They are also of importance to the pathologist because he must learn to recognize the histologic patterns which they produce and to make a correct diagnosis of the tumor. Because of their cellulosity it is very easy to label them as slowly-growing malignant tumors and thus deter the surgeon from attempting to remove them. The fact that we have been able to collect, in the past twenty years, a series of 24 cases in which this type of tumor has been removed, suggests that these tumors occur more frequently than has been generally recognized. Undoubtedly, many reported cases of this type of tumor have been lost due to the confusing nomenclature that has been applied to them.

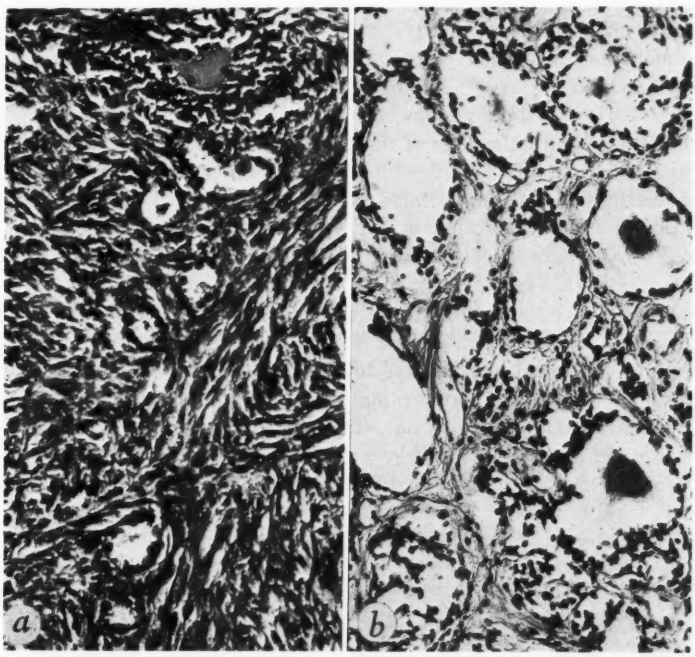

Fig. 9.—Sections of fibrous mesothelioma of pleura showing spaces containing secretion. Sections stained with hematoxylin and eosin: *a*, ×200; *b*, ×145.

It is of considerable interest that the clinical manifestations of these fibrous pleural tumors have been almost entirely extrathoracic. There can be little doubt that there is a direct association of some kind between these tumors and the attacks of chills or chilly sensations and fever; the swollen, painful, and

sometimes migratory involvement in the joints of the extremities; and the clubbing of the fingers or toes or both that occur in such a high percentage of patients with these tumors. Further evidence of this association is the prompt and complete relief of the attacks of fever and chills and the articular pain and swelling, and the gradual regression of the clubbing of the fingers and toes that have occurred following removal of the tumor in every case in which these signs and symptoms had existed preoperatively.

It is possible that the presence of clefts and glandlike spaces in these tumors has some relationship to a specific secretion by localized fibrous mesotheliomas which is responsible for the arthritic symptoms. It could be conjectured that such a secretion might be in the nature of hyaluronidase. This is suggested particularly in view of the fact that the hyaluronidase enzyme system is concerned in an ill-understood fashion in the production of certain types of arthritis. A study of the hyaluronic acid content of pleural and peritoneal fluid associated with a tumor involving the pleura and peritoneum was made by Meyer and Chaffee,[11] who found that on three separate occasions there was a constant yield of hyaluronic acid. We hope to make such a study in the future, but inasmuch as such work must be done on fresh tissue and because these tumors are rare, this phase of investigation will proceed very slowly. In one instance in our experience in which the tumor recurred four years after operation, there was simultaneous recurrence of joint symptoms and clubbing of the fingers. We are not able at this time to offer any reasonable explanation for this association. It is indeed frustrating to be confronted with such a definite relationship and not be able to understand it. We have absolutely no explanation for the production of chills and fever. Necrosis, which in other tumors is occasionally associated with the production of fever, was notoriously absent in all except 1 case.

Klemperer and Rabin[1] expressed the opinion that both benign and malignant forms of pleural mesothelioma exist. More cases must be studied over a longer time to permit one to come to any definite conclusion as to how many of these tumors are benign and how many are malignant, and what the histologic criteria for malignancy are. In one of the cases in this series histologic examination revealed unequivocal evidence of malignancy. In the other cases, the tumors, for the most part, appeared to be benign. However, in a series of cases of a new type of tumor, it is not scientifically feasible to determine which tumors are malignant and which are benign until a sufficient number of patients have been followed. We have not followed our patients long enough to determine this. To many people, the only unequivocal evidence of malignancy of an intrathoracic tumor would be embolic metastasis, and although there was clinical evidence of embolic metastasis to the skin in 1 case, this was not proved. The fact that four of the tumors recurred locally does not of necessity imply a malignant connotation. There was a recurrence of the tumor in 4 of the 22 cases in which the patients survived operation, and in all of the 4 cases the patients died of a recurrence of the tumor. However, the pathologic findings in these 4 cases were no different from those in the other cases in which there has been no recurrence.

Klemperer and Rabin[1] have reported 1 case of this type of tumor which was considered to be a low-grade fibrosarcoma when first removed. A recurrent tumor was removed subsequently. The recurrent tumor was highly malignant. This tumor ultimately metastasized to the other pleural space and the lung, and the patient died. Klemperer and Rabin postulated that repeated surgical interference was responsible for this malignant transformation. They stated that malignant transformation is observed commonly after incomplete removal of fibroblastic tissue.

The pleural effusion which was noted in 4 of our cases was not considered to be in any way associated with the malignancy of the tumor because it was not associated with implantation of the tumor in the pleural cavity. All of the tumors which were associated with pleural effusion were pedunculated tumors which were attached to either the visceral or parietal pleura by a narrow pedicle and appeared as a cauliflower-like mass projecting into the pleural cavity. It is possible that the production of fluid in such cases is comparable to that seen in the peritoneum in cases of Meig's syndrome in which various ovarian tumors, particularly fibroma with a narrow pedicle, give rise to fluid in some obscure fashion.

In view of the fact that thoracic surgeons everywhere accept the philosophy that indeterminate intrathoracic tumors must be explored, it seems likely that an increasing number of tumors of this type will be discovered. It is important that tumors of this type be kept in mind and recognized when they occur, so that unnecessarily radical operations will not be performed. It should rarely be necessary to destroy much if any lung tissue in removing these tumors. Failure to recognize the true pathologic nature of a few of the tumors in the series we have reported led to removal of normal lung tissue that could have been preserved. It is our belief that localized pleural mesotheliomas can be recognized from their distinctive histologic features alone, particularly if one is aware of the intrathoracic site of the tumors.

SUMMARY

This report is based on a series of 24 cases in which a localized fibrous mesothelioma was removed surgically. Of the 24 patients, 14 were men and 10 were women. The average age of the patients was 49.3 years. The clinical manifestations of these tumors are largely extrathoracic and are characterized in a high percentage of cases by attacks of chills, chilly sensations or fever, painful and sometimes migratory involvement of extremity, joints and clubbing of the fingers or toes or both. Prompt relief of these symptoms follows surgical removal of the tumor. There are no characteristic roentgenologic findings which permit these tumors to be distinguished from other intrathoracic tumors. Pleural effusion occurs in association with these tumors in some instances, but does not constitute a contraindication to successful surgical removal of the tumors.

Fibrous mesotheliomas are encapsulated and often are lobulated. Histologically, they are fibrogenic tumors which contain numerous whorls of collagen

and the spindle cells. They contain focal collections of cells which appear to be malignant. The most significant finding is the presence of spaces or glandlike cavities.

Localized fibrous mesotheliomas may arise from any portion of the visceral or parietal pleura. The majority arise from the visceral pleura. They rarely are situated extrapleurally.

The only effective treatment of these tumors is complete surgical removal. Localized fibrous mesotheliomas must be sharply distinguished from diffuse malignant mesotheliomas.

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DISCUSSION

DR. H. C. MAIER, New York.—I have been very much interested in this excellent presentation from the Mayo Clinic. The literature on pleural tumors was in a confused state until Dr. Arthur Purdy Stout greatly clarified the situation. He recognized the localized pleural mesothelioma on the basis of pathologic and clinical data and especially through tissue cultures done in collaboration with Dr. Margaret Murray. Previously, only the diffuse malignant pleural mesothelioma was generally recognized.

In many cases of pleural tumors that were originally designated as fibroma, leiomyoma, or sarcoma, careful search of the microscopic slide usually reveals areas with mesothelial-lined spaces such as Dr. Clagett has just shown. (Slide.) In this slide such spaces are particularly prominent. These areas were not in lung tissue but in the part of the tumor that protruded into the pleural space. I mention this point because some years ago it was thought some of these spaces might be residual alveolar spaces. One would not expect such findings in a simple fibroma or leiomyoma, as many of these tumors have been called in the past.

(Slide.) Dr. Stout has kindly loaned me this slide which summarized the data collected in his laboratory of surgical pathology at Columbia University. He has studied 62 cases of mesothelioma of the pleura sent to him from many sources. Forty of these are benign, the type that Dr. Clagett has discussed, and 22 were malignant. Of 16 cases of pleural tumor that I have seen there has been a higher percentage of the malignant variety than in this collected group of Dr. Stout's. I agree with Dr. Clagett that one must differentiate the benign localized type from the malignant diffuse type. Only five of the 16 pleural tumors that I have seen have been of this localized benign type.

I would like to show two instances of other types of pleural tumor. (Slide.) This is a pleural hemangiopericytoma in which the pulmonary osteoarthropathy was very marked in a young female.

The next case is not one of the localized type which Dr. Clagett discussed, but is a diffuse malignant lymphongioendothelioma of the pleura. (Slide.) This patient had chylous pleural fluid. The lateral recumbent film of the same patient shows the mass which was present on the pleural surface. Before her death this patient developed chyle in the peritoneal cavity. These rare cases illustrate that one can have other types of tumors develop from the pleural tissues in addition to the localized benign and diffuse malignant mesotheliomas.

DR. WILLIAM B. CONDON, Denver.—I think studies such as these presented so ably by Dr. Clagett certainly increase our knowledge of intrathoracic disease. Such studies are particularly valuable in the prognosis we can offer the patient and his relatives, and to corroborate Dr. Clagett's studies I would like to present one recent case which came to our attention.

(Slide.) This is a 66-year-old woman who had been treated for arthritis for some years, of moderately severe type, whose chest symptoms were referable to a space-occupying lesion in the left thorax. (Slide.) The lateral view shows a rather large tumor lying in the interlobar fissure which at the time of surgery presented a picture somewhat similar to this.

(Slide.) With the exception of a very few avascular adhesions to the diaphragm, the tumor lay free in the chest cavity except for a broad pedicle which sprang from the dorsal division of the left lower lobe. This pedicle contained numerous large blood vessels. The tumor was easily removed by merely placing a clamp across the pedicle.

(Slide.) On the first examination of the microscopic sections, a diagnosis of a malignant, highly cellular fibrosarcoma was made. However, when reviewed by several pathologists, the diagnosis was changed to that of a mesothelioma, which in spite of its cellularity and the number of mitotic figures, was thought to be consistent with a diagnosis of a benign type of tumor. The patient has remained free of any clinical recurrence in the last eighteen months. Her arthritis has improved markedly since surgery.

SIR CLEMENT PRICE THOMAS, London.—I would like to say a few words on this topic, not that I have anything further to contribute to what Dr. Clagett has said. We have had several cases of this type during the last few years, and the first case caught us on one foot. This was a man who had had symptoms since the age of 16. I was interested to hear Dr. Clagett state that these people have symptoms referable to conditions outside the chest. The outstanding feature of course is the arthritis or the pulmonary osteoarthropathy from which they suffer. This man's initial symptoms were in the chest and the arthritic symptoms did not commence until seven years before he came to us for treatment. Since that time—and this I think is an important fact that has come out of Dr. Clagett's contribution, on which I congratulate him—we have had 4 other cases on which we have been able to register clinically the diagnosis prior to operation, based on the points Dr. Clagett has made.

The interesting thing to me is this question of the benignancy or malignancy of these tumors. In one of my patients who had rheumatoid symptoms with swollen joints for many years, I did a local removal of the tumor but I have a vague suspicion that I left part of it behind. Exactly the same thing happened in this patient that Dr. Clagett mentioned; the rheumatoid symptoms disappeared completely after removal of the tumor. In a matter of eighteen months after removal of the tumor this patient went back to her doctor and said, "Doctor, I am getting my symptoms back; my joints are beginning to get swollen, I cannot get my rings on." The doctor sent her back to me. On x-ray examination it was found that she had a recurrence. When I re-operated on her I had to do a pneumonectomy because the tumor was infiltrating the lung tissue. As a result of the pneumonectomy the joint symptoms have completely disappeared. She is a dear fat old lady; she is short of breath but aside from that she is in pretty good fettle.

The point Dr. Clagett has raised with regard to the cause of these arthritic symptoms I think is important. I am surprised at the relative infrequency of these arthritic symptoms occurring in his cases of carcinoma of the lung. Certainly in our country they are more common with carcinoma of the lung than Dr. Clagett has mentioned, 4 cases in 200; I cannot give the figures offhand. But the important thing to me seems to be that you can get

identically the same symptoms and the new subperiosteal bone formation occurring with a series of different conditions. We get them with carcinoma of the lung undoubtedly; I have seen them with a mediastinal sarcoma; with infective conditions in the lung or pleura. I would like to postulate that it is probably not the secretion from the tumor which produces the arthritic symptoms but that the abnormal secretion from the tumor merely acts as a trigger mechanism which starts off something that produces symptoms like a rheumatoid condition. In other words, there is some sort of link in the chain farther back which can be activated by the three or four conditions which may produce the same type of symptoms.

Before I sit down I would like to reinforce what your worthy secretary has said about our own Society. He apologized to me because he called it an association. I myself am never quite sure what we call ourselves. I would also like to say how pleased I am to be here; it is a red letter day for which I have waited twelve years. Further, I would like to say that any of your members who happen to be travelling in our country at the time our Society meets will meet with a very warm welcome. If you are dreaming of coming to England—God knows why you should because we have no meat there—round about November, I suggest that you make your first port of call our Society meeting and you will be able to meet all those of us who are working in this field, and will be able satisfactorily to arrange your schedule for the rest of your trip.

RESECTION OF THE TRACHEA FOR CARCINOMA

Report of Two Cases

Bert H. Cotton, M.D., Beverly Hills, Calif., and Joao R. F. Penido, M.D. (by invitation), Rio de Janeiro, Brazil

TWO cases of primary carcinoma of the intrathoracic trachea, in which treatment consisted in complete circumferential resection of the trachea and reconstruction with a stainless steel tube, are presented. Previously reported cases of tracheal resection for cancer are briefly summarized. References examined during an exhaustive search of the recent literature on malignant lesions involving the trachea and on surgical reconstruction of the trachea are listed chronologically.

Primary tumors of the trachea are rare. Ellman and Whittaker[33] reviewed the 507 cases of this nature that had been reported up to 1945. Clagett and his co-workers[32] reported twenty-seven cases from the Mayo Clinic. The three most common primary tumors of the trachea are squamous cell carcinoma, adenocarcinoma, and cylindroma. The prognosis in cases of cylindroma seems to be better than in other malignant tracheal lesions. In 70 per cent of cases the tumor is situated in the middle or lower third of the trachea.

Treatment for primary malignant lesions of the trachea may be divided, categorically, as irradiation with x-ray, implantation of radon, endoscopic removal of the lesion with forceps or cautery, and surgical removal. The latter comprises three types of procedure: tracheotomy with curettement and cauterization of the lesion; partial circumferential or "window" resection of the trachea; complete circumferential or divisional resection of the trachea.

Of the therapeutic methods listed, complete circumferential or divisional resection would seem more nearly to achieve the ideal, that is, complete extirpation of the malignant tissue and an adequate margin of normal tissue. The hazards which may be encountered during this procedure, as well as the difficulties of technique may lead, however, to temporization with a method that, while facilitating repair, may constitute inadequate removal of the lesion.

Several cases have been reported of partial or "window" resection of the cervical trachea after a tracheotomy had been done because of cancer. A number of authors have described reconstructive procedures following resection or trauma. In 1898 Bruns[2] reported a case in which ten rings of the cervical trachea were resected for a malignant lesion of the thyroid. A tracheal cannula, of material not specified, was used as a prosthesis. His patient was well for five years following the operation; then a stricture developed and he died. In 1927 Fairchild (cited by Rob and Bateman[36]) rebuilt the cervical trachea with

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a tube of skin following complete traumatic rupture with retraction of the ends of the trachea. Rob and Bateman[36] used tantalum gauze and fascia lata for reconstruction of the cervical trachea following resection for a malignant lesion of the thyroid. Crafoord[29] rebuilt the cervical trachea with a cutaneous flap containing an implant of costal cartilage.

Resection of the intrathoracic trachea for primary malignant lesions of the trachea has been reported by six authors. In 1945 Belsey[38] rebuilt the intrathoracic trachea with wire reinforced fascia following partial circumferential resection for a primary tracheal lesion; the patient died two years later from metastasis. Clagett's[32] patient had a tracheal cylindroma. Following complete circumferential resection of the intrathoracic trachea in 1946, reconstruction was performed, using a Polythene tube as a prosthesis; however, the patient died on the sixth postoperative day. Jarvis[47] completely removed 4 cm. of the intrathoracic trachea for a cylindroma and reconstructed the trachea with a stainless steel tube; his patient died of metastasis 33 months later. Belsey,[38] in 1949, did a partial circumferential resection of the intrathoracic trachea for cylindroma and repaired the defect with wire reinforced fascia; this operation had been preceded by right-sided pneumonectomy six years before. The patient was alive at the time the case was reported, but the exact period of survival was not indicated. In 1949, Kergin[48] removed a segment of the intrathoracic trachea for squamous-cell carcinoma just above the carina and repaired the trachea with a graft of pericardium. Four months later, because of recurrence of the tumor, a pneumonectomy on the right side was done and an autogenous bronchial graft was applied to the trachea. The patient died, however, on the third postoperative day. In 1950, Cahan[45] resected the intrathoracic trachea for adenoid cystic carcinoma. A graft of tantalum gauze and fascia lata was used as a prosthesis. Ravitch[46] mentioned two cases of carcinoma involving the trachea. Paulson used a wire reinforced fascial graft for reconstruction. Ravitch reports tantalum mesh and a dermal graft for reconstruction.

Three of these intrathoracic resections were complete circumferential or divisional resections (Clagett,[32] Jarvis,[47] Ravitch[46]). Only one report (Jarvis[47]) indicated a successful initial result.

In the cases of primary carcinoma of the intrathoracic trachea presented here, a combined cervical and sternum splitting incision was employed, with a right-sided thoracotomy through the second anterior interspace. A complete circumferential resection of the trachea was done and a stainless steel tube was employed for reconstruction of the air passage. In both cases the results have been encouraging. The patients are alive and well sixteen and six months, respectively, following extirpation of their malignant tracheal lesions. Neither has had recurrence of symptoms; evidence of reactivation of the malignant process has not appeared.

CASE REPORTS

CASE 1.—In January, 1951, T. P. M., a 58-year-old white man, was seen with the complaints of wheezing, coughing, hemoptysis, considerable difficulty in breathing, and a loss of 25 pounds. He could walk only about 20 yards.

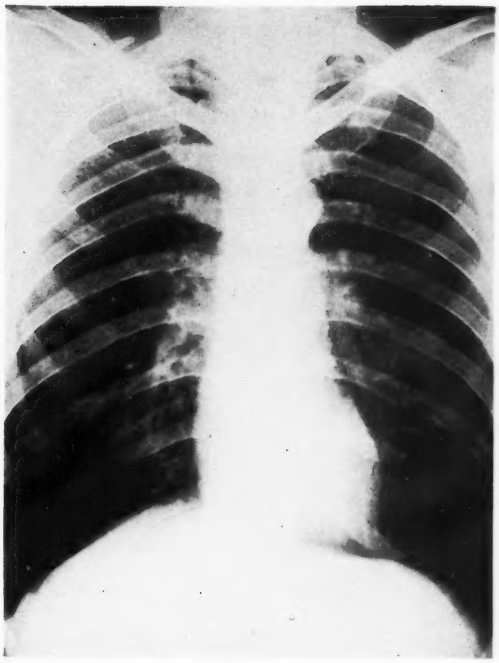

Fig. 1.—Case 1. Preoperative film showing bilateral emphysema due to the partially obstructive tracheal lesion.

Fig. 2.—Case 1. Lateral view showing tumor mass.

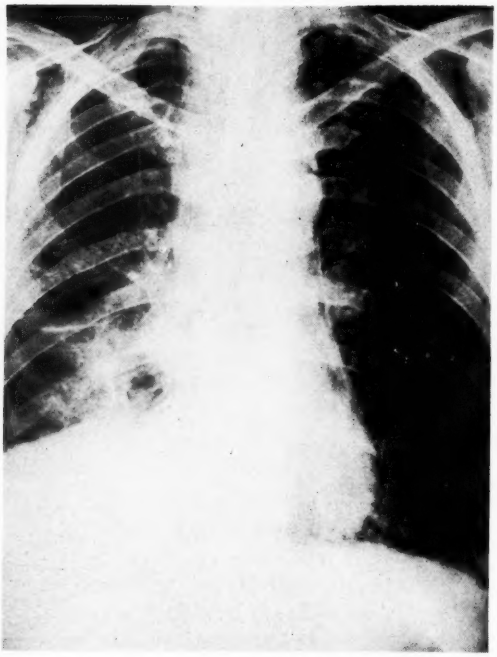

Fig. 3.—Case 1. Fourth postoperative day showing the subcutaneous emphysema and position of the three-inch tube.

Fig. 4.—Case 1. Lateral view of Fig. 3.

Fig. 5.—Case 1. The tube is shown displaced downward with angulation to the right. The wire stitches can be seen above the tube.

Fig. 6.—Case 1. Laminogram showing the stenosis above the tube.

On examining the patient, his recent loss in weight was obvious. A marked stridor was noted, but evidence of metastasis was not found. A roentgenogram of the chest demonstrated emphysema of both lungs. On bronchoscopy a tumor was seen just below the cricoid cartilage which almost completely filled the lumen. Biopsy of the tumor was reported as carcinoma.

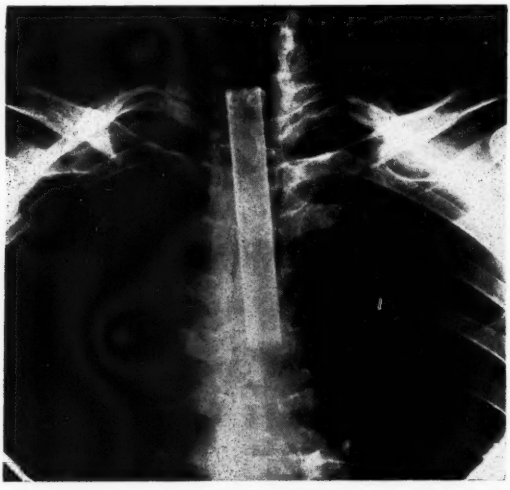

Fig. 7.—Case 1. New four-inch tube anchored in place.

Fig. 8.—Case 1. Lateral view of new tube.

On Jan. 15, 1951, the trachea was exposed by a midline cervical incision. After the trachea was opened, the lesion was found to extend almost to the carina. A sternal-splitting and right thoracotomy incision was made into the second interspace anteriorly. The trachea was resected from the cricoid cartilage to a point 2.5 cm. above the carina, the entire circumference of the trachea being removed.

Reconstruction of the air passage was effected by inserting a stainless steel tube. Intravenous anesthesia was used, and adequate oxygenation was provided through a long, sterile, endotracheal catheter inserted through the wound and held snugly in the lower part of the trachea by umbilical tape. A stainless steel tube 7.5 cm. long, which extended 0.5 cm. into each tracheal segment, was sutured in place with multiple wire sutures. Since a tracheostomy could not be done because of the extent of the resection, an indwelling endotracheal catheter, passed through the nose into the trachea, was employed for three days to control the mucus and effect free passage of air. It served also to prevent the patient's closing his vocal cords when coughing, thus preventing, in turn, subcutaneous emphysema. On the third postoperative day, however, subcutaneous emphysema did appear which was thought to be caused by obstruction of the endotracheal catheter. This proved to be the case. The lower end of the catheter was almost completely obstructed by blood and mucus. It was not found necessary to reinsert the catheter. The remainder of the patient's hospitalization was without complications, and he was discharged on the tenth postoperative day.

After an uneventful convalescence, with complete relief from his symptoms, the patient returned to full-time work.

Nine months later, in September, 1951, while painting a ceiling, the patient inhaled some dust which caused a severe attack of coughing. For the next few days he had an irritating cough; he was also having difficulty on inspiration. Roentgenologic examination revealed that the steel tube had slipped downward about 3 cm.; both lungs were adequately aerated. Bronchoscopy confirmed that the tube had slipped; the exposed portion of the reformed trachea was mobile and was filled with polypoid granulation tissue. Many polypoid masses were removed, following which the patient's symptoms were somewhat relieved. On the two succeeding days additional polypoid masses were removed bronchoscopically. Microscopic studies of the tissues revealed no recurrence of the malignant growth. Further symptomatic relief had been effected by the repeated bronchoscopic therapy; however, about ten days later increasingly severe stridor appeared. Bronchoscopy at this time revealed a firm annular stenosis with a lumen of only 3 to 4 mm. On Sept. 21, 1951, he was operated upon. The tube was found to have slipped. The stenotic area was curetted and the tube resutured into place with No. 0 cable wire. The patient had a complete and uneventful recovery and resumed full-time work in an airplane factory. All of his previous symptoms disappeared.

On April 7, 1952, he contracted a severe upper respiratory infection which was accompanied by a great deal of coughing. Following this, stridor developed. Roentgenologic examination indicated the tube had again slipped and that stenosis had developed at the same site as before. On April 15 a new tube was inserted and anchored in place with No. 28 wire sutures. He immediately lost all his symptoms; he was able to leave the hospital in five days. Tissues removed at this time again were free of evidence of recurrence of the carcinoma. The entire air passage still was mobile and was lined with polypoid masses of granulation tissue with exception of the upper 3 cm. which constituted a heavy rigid fibrinous wall that was the site of the stenosis.

Sixteen months now have elapsed since removal of the malignant lesion; there is not, at present, any evidence of recurrence.

The wire sutures used in the previous operations were, in each instance, found to be broken. In retrospect I feel that the suture material was not strong enough to anchor the tube. We hope that the No. 28 wire will be adequate. At no time has there been evidence of stenosis at either end of the steel tube where it is in contact with the tracheal mucosa.

CASE 2.—On Oct. 30, 1951, W. W., a 53-year-old white man, was seen with the complaint of progressively severe wheezing of four months' duration. For the last two weeks he had had pronounced respiratory embarrassment. He was being treated for asthma.

Fig. 9.—Case 2. Postoperative film showing two-inch tube in place.

Fig. 10.—Case 2. Lateral view of Fig. 9.

The patient appeared well nourished. He had a marked stridor. Roentgenograms of the chest were essentially normal. Bronchoscopic examination revealed a tumor in the middle third of the trachea which had the typical appearance of a bronchial adenoma; it almost completely obstructed the lumen except for a narrow passage along the right wall. Biopsy was reported as benign tracheal adenoma. However, and in the face of opposition from the entire hospital tumor board, it was decided to perform a complete circumferential divisional resection of the trachea.

On Nov. 1, 1951, a segment of the thoracic trachea 3.8 cm. long was removed, and reconstruction of the trachea was effected by insertnig a stainless steel tube 5 cm. in length in a manner similar to that employed in Case 1. Histologic examination of the tissues removed revealed the lesion to be an adenocarcinoma. As in Case 1, an indwelling endotracheal

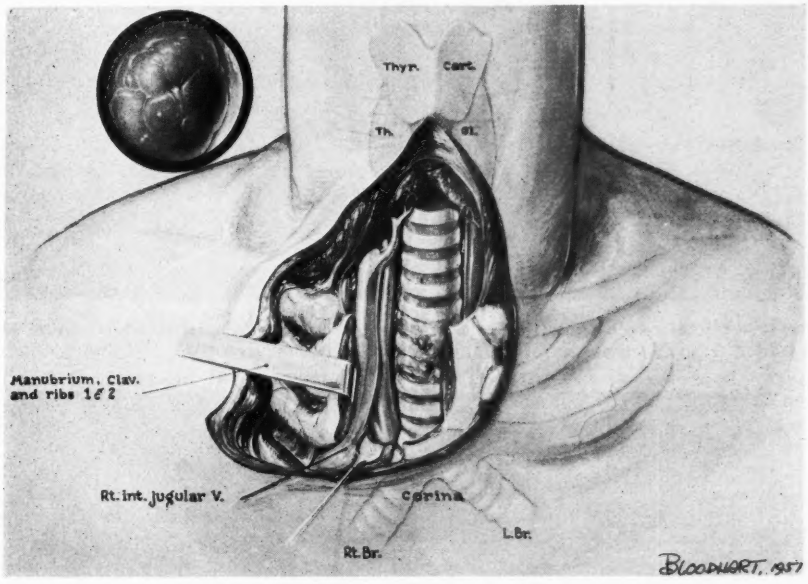

Fig. 11.—Exposure of the lesion through a cervical, sternal splitting and right thoracotomy incision. The insertion is a bronchoscopic view of the lesion.

catheter was introduced through the nose for removal of mucus postoperatively. This was satisfactory until the fourth postoperative day when subcutaneous emphysema appeared. The catheter was immediately removed; it was found to be obstructed by a laminated clot of blood and mucus. The patient's postoperative course was uneventful thereafter, and he left the hospital fourteen days after the operation. On bronchoscopic examination in April, 1952, the steel tube was seen to have remained in place and there was no evidence of granulation tissue.

DISCUSSION

A combined cervical sternal splitting incision with a right-sided thoracotomy through the second anterior interspace gave adequate exposure for resection of the trachea.

Postoperatively, an indwelling endotracheal catheter introduced through the nose permitted adequate control of mucus and prevented closure of the

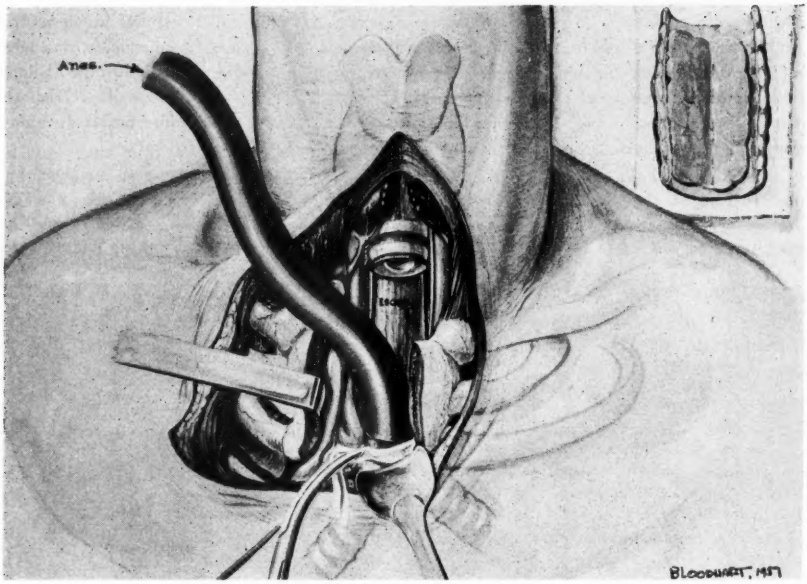

Fig. 12.—Trachea resected with lesion shown in the insertion. Long anesthesia tube shown held in lower end of the trachea.

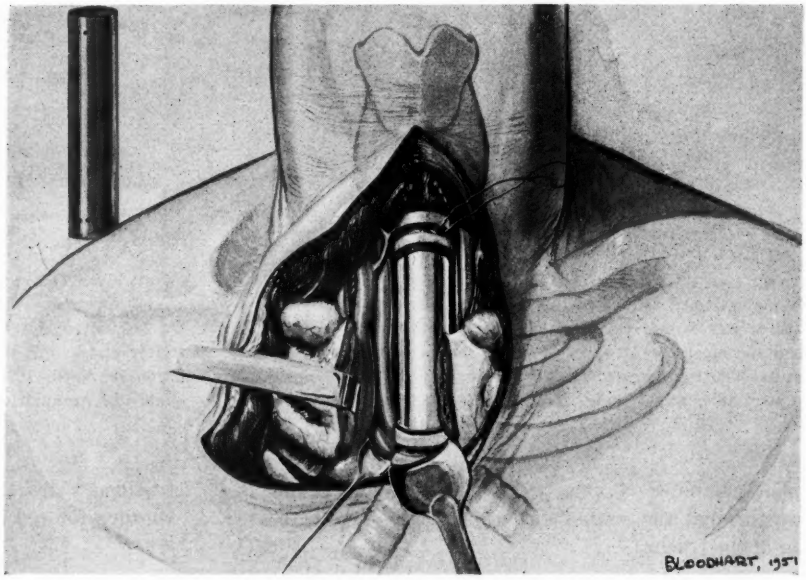

Fig. 13.—Three-inch stainless steel tube in place.

vocal cords, thus minimizing subcutaneous emphysema; the catheter was well tolerated by both patients. It had to be removed three and four days, respectively, following operation because of obstruction by blood-stained mucus. In neither instance was reinsertion of the endotracheal catheter required.

Because mass ligatures were not used in either case, the closure of the trachea was not airtight; however, subcutaneous emphysema did not occur until the third day.

Intravenous anesthesia was used. Adequate oxygenation was provided by the use of a supplementary, sterile, long endotracheal tube inserted through the operative wound and held snugly in the lower part of the trachea by umbilical tape.

Postoperative infection was not encountered. Penicillin, 100,000 units every three hours, was employed during the postoperative period.

A stainless steel tube was anchored with mattress wire sutures through holes in the tube and then through the trachea. The tube extended 1 cm. into each segment of the trachea. No. 28 wire proved to be the best choice of suture material.

SUMMARY

1. Two cases of combined cervical and intrathoracic resection of the trachea are presented. Both patients are alive and well sixteen and six months, respectively, following extirpation of the malignant tracheal lesion.

2. Complete circumferential or divisional resection more nearly achieves the ideal treatment for primary neoplasm of the trachea than does any other method of therapy.

3. Reconstruction of the trachea with a stainless steel tube was adequate.

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DISCUSSION

DR. O. THERON CLAGETT, Rochester, Minn.—My colleagues and I have been interested in this problem of tracheal tumors for some time, having begun the development of techniques for the reconstruction and repair of the trachea in 1946. To date we have performed operations on four patients with tracheal tumors. In our total experience with tracheal tumors the most common type is squamous cell carcinoma. Cylindroma is the second most common, adenocarcinoma is third, and hemangioendothelioma is fourth. We do not believe that it is technically possible to perform a really radical operation, in terms of cancer

surgery, for tumors of the trachea. The best that can be accomplished is a local excision of the growth. For this reason we believe that resection of cylindromas of the trachea offers our best surgical opportunity since they are slow-growing tumors which metastasize late.

Of the four patients upon whom I have operated, three had cylindromas, one was a squamous cell carcinoma. All of these tumors involved the right lateral wall of the trachea. This was fortunate since this region is most accessible to surgical attack. In our first case it was necessary to resect the lower third of the trachea and the right lung. The trachea was joined to the left main bronchus with a long Polythene tube. This patient died of pneumonia on the sixth postoperative day due to obstruction of the left upper lobe bronchus by the tube. Our second patient had a small tumor. A window resection of the right lateral wall of the lower trachea was carried out and the defect was repaired with a fascial patch reinforced and contoured with steel wire. This patient is still well two and one-half years after operation. Our third patient had a squamous cell carcinoma involving the right lateral wall of the middle third of the trachea. Regional lymph nodes were involved. A large window of trachea was resected. This defect was too large for repair with a fascial patch so a Polythene tube was inserted. This patient died of recurrent and metastatic carcinoma about two years later. However, the Polythene tube provided an adequate airway throughout most of this period. Our fourth patient had a large cylindroma involving the right lower trachea and part of the right main bronchus. The tumor was resected and the defect repaired with a wire-reinforced fascial patch. It was necessary to remove the wire from the trachea a few months after operation by means of bronchoscopy, due to excess granulations at the site of repair and excess cough. One year after operation this patient is getting along well.

I do not believe that a wire reinforced fascial patch is a satisfactory method of repair for large tracheal defects. However, it has worked well clinically and experimentally for small defects. Our experimental results with polythene tubes has been very satisfactory. Our clinical results have not been discouraging. However, we must continue our search for better methods for repair and reconstruction of the trachea. Tracheal tumors are rare, but patients who have them deserve our best efforts to relieve them of their progressive cough, dyspnea, and choking. A technical point that should be mentioned is to emphasize the importance of performing cervical tracheotomy at the time of operation in every case. This procedure adds immeasurably to the safety of the patient during the early postoperative course.

DR. EARLE B. KAY, Cleveland.—I certainly enjoyed Dr. Cotton's excellent paper. I have also been interested in this problem for the past several years and have operated upon seven patients with various types of tracheal lesions. Four patients had extensions of bronchogenic carcinoma into the lower trachea from lesions originating in the right lung, which necessitated wedge or elliptical excisions of the lower trachea and carina. The other three patients are of particular interest in reference to tracheal surgery and I would like to refer to the operative procedures employed. Because of the incidence of complications associated with the use of prostheses, the surgical reconstruction of the tracheobronchial tree in each case was accomplished by the adequate mobilization of the proximal and distal segments and primary anastomosis.

The first patient to be discussed had a large leiomyoma of the upper trachea. The tumor area including the upper five tracheal rings and posterior one-half of the cricoid cartilage was resected. The distal trachea and upper main stem bronchi were mobilized sufficiently to allow for a primary anastomosis. A temporary tracheotomy was performed distal to the anastomosis. Healing was excellent. There has been no evidence of stenosis during the two-year follow-up.

The second patient had an adenocarcinoma arising in an adenoma in the distal trachea and carina. It was necessary to resect the distal trachea as well as the carina and upper segments of the right and left main stem bronchi. The proximal trachea and distal bronchi were mobilized, the carina reconstructed and a primary tracheobronchial anastomosis effected. The operation was performed through a right thoracotomy incision. Thoracotomy drainage

was instituted for four days postoperatively. The convalescence was uneventful. The patient is alive one year postoperatively without evidence of recurrence at the primary site but with evidence of mediastinal glandular metastasis.

The third patient was operated on about a month ago. He had a carcinoma of the right lung which had extended into the lower trachea and left main stem bronchus. A right pneumonectomy was performed including about one inch of the lower trachea and about two-thirds of the left main stem bronchus. Then by mobilizing the trachea above and the entire hilar region of the left lung, sufficient mobilization was obtained to approximate the ends. As is seen in the slide of the surgical specimen the disproportion between the larger tracheal lumen and the smaller size of the bronchus was overcome by invaginating the distal bronchus into the trachea and then performing an anastomosis by individual suture technique. As is noted on the screen the anastomosis was just above the left main stem bronchus. This patient died six days postoperatively from an acute myocardial infarction. Healing of the anastomosis appeared excellent for this stage.

DR. OSLER ABBOTT, Atlanta.—There are two matters felt to be worthy of discussion. One is that I do not think discussion of this problem will in any way be complete unless we pay due credit to Rollin Daniel for the work he presented to this Association on the experimental aspect. Two, I thought it might be of some interest to let you know of the follow-up on the six patients on whom we did resection of the lower trachea and carina and reported to the Association, by title, three years ago. It only adds emphasis to what has been said, and for that reason I bring it up.

Five of the cases of carcinoma with extension were brought to light because of the enthusiasm of the young surgeon. The palliation was not justified. Prostheses with glass tubes were used in two patients, one of whom developed discomfort. The tube was removed, apparently ill-advisedly, after nine months, and was followed by stenosis and death, no post mortem was done. The sixth patient had a cylindroma, primarily of the carina. This patient had a right pneumonectomy, and had a reconstruction of the carina by the early method that we described for repair of the trachea and left main-stem bronchus. That repair gives a very difficult postoperative course and for that reason is to be condemned. Other than that, the ultimate result was excellent. This patient with a cylindroma lived for three years and nine months and died from abdominal metastasis after an x-ray diagnosis had revealed carcinoma of the stomach. So, for this reason, I feel I could emphasize Dr. Clagett's point to use this as much as possible for relatively benign lesions.

DR. J. E. MAC MANUS, Buffalo, N. Y.—I would like to subscribe to Dr. Cotton's principles and those of Dr. Kay in the handling of primary lesions of the trachea. I believe we should treat them as we do other tubular organs, with segmental resection and whatever nodal resections seem appropriate. In view of the fact that the esophageal chain, the tracheal chain and the hilar-bronchial chain are so intimately associated, it is not very likely that we will do adequate cancer surgery, but I do believe that segmental resection with primary anastomosis should be our objective.

I would like to add one case to Dr. Kay's cases that he has presented, of a patient who had a primary lesion of the trachea with a segmental circumferential excision of the lesion and a primary anastomosis. This was an intrathoracic lesion measuring approximately 3.2 centimeters in size.

(Slide.) This is the lipiodol study of the patient before surgery, a 59-year-old man with hemoptysis as the only symptom. The lipiodol runs down the anterior wall of the trachea and you can see it outlining the tumor quite satisfactorily. We did this because we wanted to be certain of the exact location of the lesion, feeling that since the pathologist reported a very mature squamous cell lesion, we might have difficulty in finding it with the intratracheal tube in the trachea if we did not know exactly where it was beforehand.

(Slide.) This shows the resected lesion. The segment comprised three cartilages anteriorly and six posteriorly. As we all know the cartilage bifurcates shortly after passing lateralward. That amounts to a segment of trachea approximately 3.2 centimeters in width.

(Slide.) This demonstrates the lesion to be adequately resected, at least locally, by turning it inside out and allowing us to view the area of local attachment.

(Slide.) After studying the sections our pathologist changed his diagnosis from a very mature squamous cell carcinoma to a cylindroma, but I believe, as many of you do, that the cylindroma is fundamentally a malignant tumor.

(Slide.) This is the trachea after resection. One can see the outline of the tracheal wall. By direct endoscopic visualization the suture line was entirely healed in seventeen days with no less of lumen.

DR. OTTO C. BRANTIGAN, Baltimore.—Dr. Cotton in his very consise manner has given us as usual an excellent presentation, and I wish to congratulate him on the good results he has obtained. I arise merely to say a word about our experience in work on the trachea. Experimentally, Dr. Penton conceived the idea of a viable, living pedicle made from the chest wall. The pedicle includes pleura, periosteum, intercostal artery, nerve, vein and intercostal muscles. We could remove in the dog the complete circumference of the trachea or any part of it and repair the defect with the viable pedicle and have uniform recovery of the animal. We have not had a patient with carcinoma of the trachea. However, in dealing with an individual with carcinoma of the esophagus where we got into a situation that had to be finished, we had the opportunity of applying this technique when an extensive excision of the trachea had to be repaired.

After excision of the carcinoma from the trachea there was a defect of more than half the posterior circumference of the trachea and both major bronchi, and extending a distance of about one inch on both major bronchi and about two to two and one-half inches of the lower end of the trachea. The viable pedicle flap of the chest wall was used to repair this defect. No support was used in the flap. However, a soft rubber tube was placed in each bronchus and brought out by way of the trachea through a tracheotomy wound in the neck. These tubes were removed within six days. The patient made an uneventful recovery. Unfortunately, he died of generalized metastasis about four months after operation.

DR. COTTON.—(Closing.) In closing I would like to show a specimen to demonstrate how clean the tube remains.

(Slide.) This stainless steel tube was inserted for an aneurysm which was causing tracheal obstruction. The patient died three months after insertion, but I show this to demonstrate how clean the tube remained even though it was in the trachea for three months.

May I thank the discussors for their remarks.

THE SURGICAL TREATMENT OF CARCINOMA OF THE HYPOPHARYNX, LARYNX, AND UPPER ESOPHAGUS

ORVILLE F. GRIMES, M.D., AND H. BRODIE STEPHENS, M.D.
SAN FRANCISCO, CALIF.

THE over-all decrease in the mortality rates for surgery of the esophagus and hypopharynx has encouraged an ever broadening horizon with respect to the aggressive surgical attack on such lesions. The rare operation of ten years ago has now become an almost commonplace procedure. Credit for this belongs not only to those who have perfected the technical details of the operative procedures but also to improvements in anesthesia and to the contributions of physiologists who have solved so many of the problems of the pulmonary and cardiovascular systems. Chemotherapy and the antibiotic agents have added their increment of improvement in combating and preventing infections, and adequate whole blood replacement therapy during surgery has permitted the confident performance of a deliberate and unhurried operative procedure.

Cancer of the hypopharynx, upper esophagus, and larynx is more closely related to the intra-oral group of carcinomas than to the gastrointestinal malignancies of glandular origin. The resemblance is evident in that epidermoid carcinoma is the common histologic type, the age and sex distribution are similar, and there appears to be a common etiologic relationship to chronic irritants of various sorts. Contrary to true esophageal cancer which often metastasizes early and widely, carcinoma which arises in the larynx and spills over into the hypopharynx or that which arises in the hypopharynx and secondarily involves the larynx or the upper esophagus often tends to remain localized, and its metastases frequently are limited to the cervical lymphatic chains for a considerable period before ultimate more rapid distant dissemination occurs.

During the past three years (from March, 1949, through March, 1952) seventeen patients with advanced malignant lesions involving the hypopharynx, larynx, and upper esophagus have been treated surgically at the University of California Hospital. The procedure popularized by Wookey[1] of Toronto has been applied and in the majority of the patients treated has been extended to include a unilateral radical neck dissection. The operation is designed to provide a wide en bloc excision of all malignant tissue.

A rectangular flap of skin and subcutaneous tissue is raised on the anterolateral surface of the neck with its hinge on the side corresponding to the location of the lesion within the hypopharynx. If definitely enlarged cervical lymph nodes are present unilaterally, a standard radical neck dissection is accomplished before the site of the primary lesion is attacked.

After completion of the neck dissection, the isthmus of the thyroid gland is divided along with the sternal attachments of the infrahyoid musculature.

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Read before the Thirty-second Annual Meeting of The American Association for Thoracic Surgery, Dallas, Texas, May 8-10, 1952.

The trachea is preferably divided at the cricoid cartilage, but may be transected at a much lower level depending upon the downward extent of the tumor. Such extension usually is manifested externally by a mass intimately adherent and roughly parallel to the larynx and trachea. Anesthesia is thereafter administered through a right-angled, inflatable, cuffed rubber tube placed directly into the open end of the trachea which is exteriorized in the region of the suprasternal notch. The esophagus is transected at a similar level. All or part of the contralateral thyroid lobe is preserved, mainly to insure adequate parathyroid function.

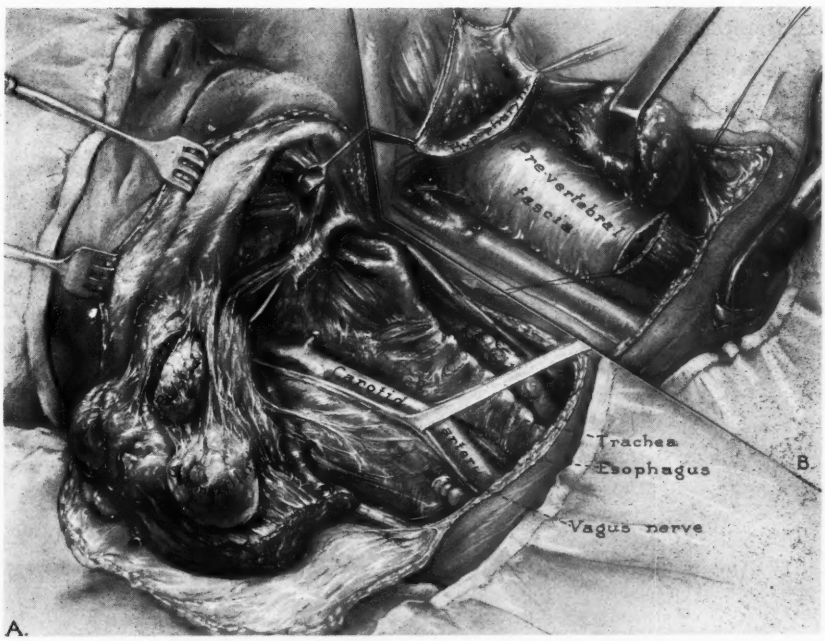

Fig. 1.—*A*, The skin flap has been reflected toward the right side along with the contents of the radical neck dissection. *B*, The tracheal segment, upper esophagus, larynx, and hypopharynx have been removed en bloc on the plane of the prevertebral fascia. The trachea has been exteriorized.

An upper incision is carried into the hypopharynx through the thyrohyoid membrane. In most instances the hyoid bone can be preserved. However, partial or total excision of the hyoid is feasible if warranted by the extension of the lesion, and, surprisingly enough, produces little or no difficulty in swallowing.

The plane of dissection, once the trachea and esophagus are transected inferiorly, is easily established. The entire tracheal segment, larynx, hypopharynx, and upper esophagus are rather easily mobilized and removed on the plane of the prevertebral fascia. The hypopharynx is transected as far superiorly as possible. Almost always it is wise to remove a portion of the base of the tongue (**Fig. 1**).

Occasionally the carcinomatous lesion may extend upward along the lateral hypopharynx to levels as high as the tonsillar fossa. Regardless of the severity of the proximal involvement, adequate triangular excision of the malignant extension can usually be accomplished (Fig. 2). The repair of the resulting hypopharyngeal defect necessarily decreases the caliber of the pharyngeal stoma, but apparently not excessively so.

The first stage of the procedure is completed by partially reconstituting the swallowing mechanism. The flap of skin and subcutaneous tissue is utilized to form a skin-lined swallowing tube. The flap is swung back across the prevertebral fascia and sutured circumferentially to the hypopharynx above and to the transected end of the esophagus below, forming what is termed the "lateral

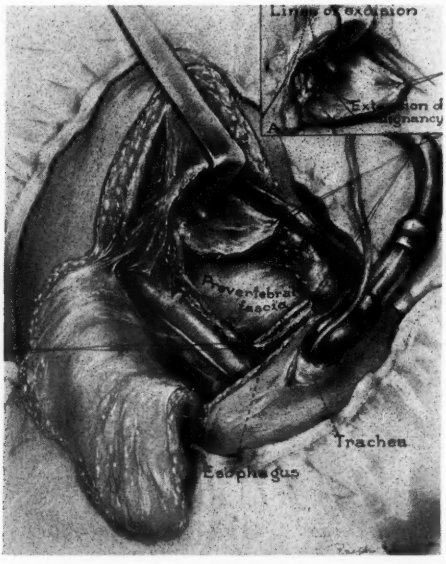

Fig. 2.—Large segments of the lateral hypopharyngeal wall and the base of the tongue frequently must be excised because of the proximal extent of the lesion.

sinus" (Fig. 3). A Polyethylene tube is inserted through this area into the stomach for feeding purposes during the interval between the first and second stages of the procedure. The excess margins of the skin flap are sutured to the surrounding skin edges (Fig. 4). Frequently skin grafts are necessary to close the raw areas. The lower regions of the wound receive soft rubber drains.

A waiting period of three months is usually necessary before the second stage of the procedure may be safely accomplished. During this interval the blood supply of the partially formed swallowing tube is insured by the development of new vascular channels directly from the tissues deep to the transposed skin flap.

The swallowing mechanism is completed by appropriate vertical and horizontal incisions designed to mobilize enough of the skin flap to close the

Fig. 3.—The circumferential union of the skin flap to the hypopharynx and esophagus forms the lateral sinus.

Fig. 4.—After insertion of a polyethylene catheter through the completed skin-lined tube into the stomach for feeding purposes, the surrounding skin edges are sutured to the excess margins of the skin flap.

lateral sinus. In the majority of instances the closure is easily performed, since the circumferential suturing both to the hypopharynx and to the esophagus has been completed at the initial stage of the procedure. However, necrosis from an inadequate blood supply may follow the extensive neck dissection necessary to excise large metastatic cervical masses, and a portion of the skin flap may be lost. In such instances, the skin-lined swallowing tube may still be completed by a wider mobilization of skin and subcutaneous tissue. A double row of nonabsorbable sutures is preferred. The raw external surface is covered by a skin graft of intermediate thickness. An ideal dressing with localized pressure is provided by fluffed gauze secured with the sutures used to anchor the skin graft.

Twelve patients of the seventeen operated upon are alive from one to thirty-six months after surgery (Table I). Nine of these patients are well, and have shown no evidence of recurrence for from one to twenty-four months. Some have returned to gainful employment. Three patients have tiny pin-point fistulas which thus far persist in spite of all efforts designed for their closure. Fortunately, however, they experience little or no difficulty in swallowing.

TABLE I. HYPOPHARYNGEAL CARCINOMA ANALYSIS OF SURVIVING CASES

	NAME	SEX	AGE	PRIMARY LESION	TIME SINCE OPERATION (MONTHS)	COURSE	PRESENT STATUS
1.	Q. Q.	M	48	Esophageal carcinoma	36	Lumbar spine metastases 20 months after surgery R with roentgenogram	1. ? Bone metastasis, left femur 2. Probable cervical lymph node metastases
2.	E. R.	M	52	Hypopharynx	24		1. No evidence of recurrence 2. At work
3.	A. W.	M	70	Invasive thyroid carcinoma	17		1. No evidence of recurrence 2. Small salivary fistula
4.	P. R.	M	71	Hypopharynx	13		1. No evidence of recurrence 2. Small salivary fistula
5.	W. J.	M	49	Hypopharynx	12		1. No evidence of recurrence 2. At work
6.	W. K.	M	55	Hypopharynx	11		1. No evidence of recurrence 2. Small salivary fistula
7.	D. S.	M	71	Hypopharynx	11		1. Cervical lymph node metastases
8.	J. M.	M	53	Hypopharynx	7	Hemorrhage 4 months after surgery	1. Recurrence, local
9.	R. M.	M	70	Hypopharynx	5		1. Well
10.	H. M.	M	52	Hypopharynx	2		1. Well
11.	F. McF.	M	49	Hypopharynx	1	One-stage procedure	1. Well
12.	G. L.	M	53	Hypopharynx	1	One-stage procedure	1. Well

The first patient in this series (Q. Q.) presented the problem of cervical esophageal carcinoma with direct extension into the larynx. The lowermost level of the lesion in this 48-year-old Chinese laundryman was at the level of the clavicle. Because of the length of the involved area, the skin flap was of greater width than usual. Consequently, the trachea was brought out lateral to the usual midline suprasternal position. Fig. 5 demon-

Fig. 5.—Note the minimal external deformity produced by the extensive removal of malignant tissue.

Fig. 6.—The tracheostomy is evident in the suprasternal notch. The irregular defects in the anterior wall of the skin-lined swallowing tube healed without impairment of function. The gastric tube traversing the area remained in situ until healing had occurred.

strates the completed second stage of the procedure. The large raw areas produced by the extensive dissection required considerable skin grafting. The skin-lined swallowing tube still functions well. Three years have elapsed since the original operation. Metastases in the lumbar spine which developed twenty months after surgery are under fair control with roentgen therapy.

A 70-year-old man, a teacher of English literature (A. W.), presented an interesting problem. Three subtotal thyroidectomies for recurrent carcinoma of the left thyroid lobe had been performed since 1936 when the diagnosis was first established. Dysphagia and hoarseness due to invasion of the esophagus and larynx had developed to an alarming degree by November, 1950, when the patient was first seen at the University of California Hospital.

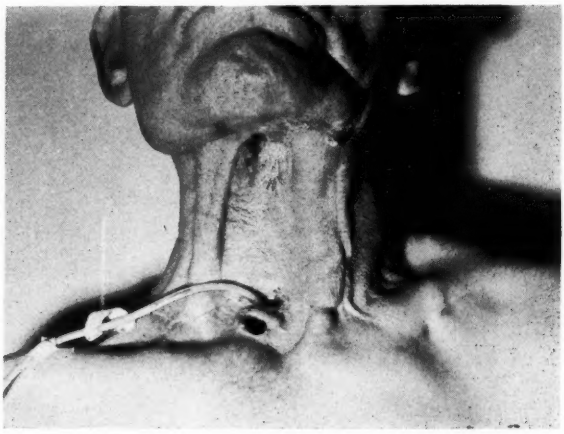

Fig. 7.—The completed first stage of the procedure. The lateral sinus joins the hypopharynx above with the esophagus below. A right radical neck dissection has been accomplished.

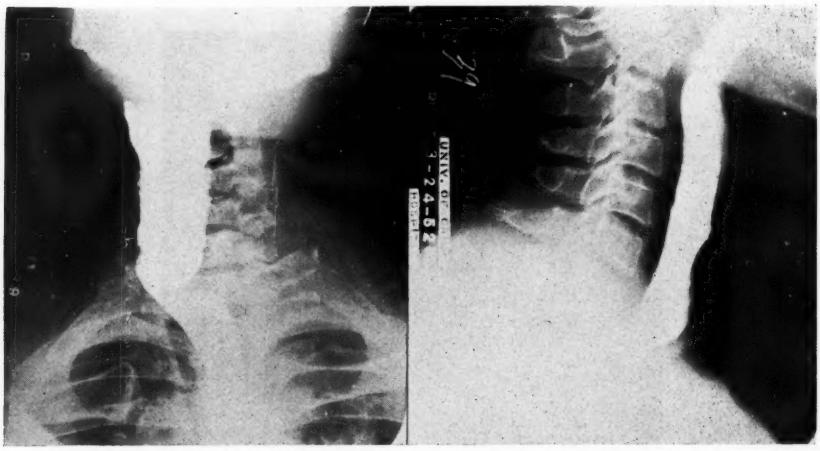

Fig. 8.—Some degree of narrowing can be expected at the anastomosis of the esophagus with the skin-lined tube. All patients in the series have been able to tolerate semisolid to solid foods without difficulty.

Since the invasive thyroid carcinoma failed to take up radioactive iodine in sufficient quantities to be therapeutically effective, extensive surgery was the only alternative. In spite of some necrosis of the skin flap at the second stage of the procedure (Fig. 6), the skin-lined swallowing tube has healed and functions well. No evidence of recurrence can be demonstrated seventeen months after excisional therapy.

A 71-year-old Italian man (P. R.) with a carcinoma of the hypopharynx and upper esophagus had symptoms for only three months. The malignant lesion extended upward along

the midline of the posterior wall of the hypopharynx to the level of the uvula. The narrowed hypopharyngeal stoma resulting from the excision of the malignant extension (Fig. 7) has not interfered with swallowing since the completion of the second stage of the procedure.

A 49-year-old white man, a janitor, had an extensive lesion of the right pyriform sinus with unilateral cervical lymph node metastases. Roentgen studies of the skin-lined swallowing tube demonstrate the adequate caliber and function of the mechanism (Fig. 8). There is no evidence of recurrence, and he has returned to his usual occupation twelve months after the original surgery.

TABLE II. HYPOPHARYNGEAL CARCINOMA OPERATIVE DEATHS

	SEX	AGE	PREVIOUS THERAPY	NUMBER OF DAYS	CAUSE
M. A.	M	54	X-ray	54	1. Hemorrhage 2. Empyema
M. W.	F	68	None	14	1. Hemorrhage 2. Respiratory distress

There were two operative deaths in the series (Table II), one two weeks, the other fifty-four days after surgery, both from complications associated with postoperative hemorrhage. One fatality occurred in a 68-year-old white woman with an extensive carcinoma of the cervical esophagus with tracheal and laryngeal involvement. Because of the length of the involved area, the trachea and esophagus were transected at a low level below the suprasternal notch. Two episodes of hemorrhage during the first ten days after surgery were controlled with pressure dressings. Bleeding again recurred on the fourteenth postoperative day. The patient apparently became asphyxiated from blood which dropped directly into the low-lying trachea in spite of all efforts that were made to prevent such an occurrence.

The other operative death occurred in a 54-year-old Italian man who had previously received approximately 12,000 roentgen units to the anterolateral neck regions in an effort to control an extensive carcinoma of the larynx with secondary hypopharyngeal involvement. The presence of metastatic carcinoma in the right deep cervical lymphatic chain necessitated a unilateral neck dissection. Because of the impairment of the blood supply of the skin flap from the previous roentgen therapy and the development of postoperative infection, necrosis of the right common carotid artery occurred. It was necessary to ligate this vessel at its origin from the innominate artery through an anterior thoracic approach. An extensive empyema resulted, causing the patient's death fifty-four days after the initial surgery.

TABLE III. HYPOPHARYNGEAL CARCINOMA ANALYSIS OF FATAL CASES

	SEX	AGE	PREVIOUS THERAPY	SURVIVAL TIME (MONTHS)	CAUSE OF DEATH
F. B.	M	57	X-ray	12	1. Local recurrence 2. ? Widespread metastases
J. N.	M	64	0	14	1. Persistence of carcinoma 2. Widespread metastases
A. Mc.	M	58	0	26	1. Cervical L.N. metastases 2. ? Local recurrence hypopharynx

In addition to the two operative deaths, three other patients undergoing surgery for extensive lesions in and about the hypopharynx have died during the period of study. The survival period in these three patients varied from twelve to twenty-six months (Table III). In one instance (J. N.) the bilateral extent of the cervical lymph node metastases was not immediately apparent at the time of the first-stage operation. Because of the persistence of carcinoma in the anterior neck regions and the development of generalized metastatic deposits, the patient died fourteen months after surgery without ever having the swallowing tube completed. In retrospect, surgery should not have been attempted. Two other patients developed local recurrences as well as distant metastases which caused their deaths twelve and twenty-six months, respectively, after surgery.

Cervical lymph node metastases were present in fourteen of the seventeen patients in the series. In one instance, already mentioned, bilateral metastases were present, although this fact was not apparent in the original evaluation of the patient. In one case, in spite of the presence of unilateral lymph node metastases, a radical neck dissection was postponed, since the patient's general inventory suggested that the procedure might best be accomplished in stages. After completion of the skin-lined swallowing tube, a radical neck dissection was attempted, but at this late date the metastatic nodes were densely adherent to the right common carotid artery at its bifurcation and could not be removed. The wiser choice would have been the combined procedure at the original operation regardless of the greater risk.

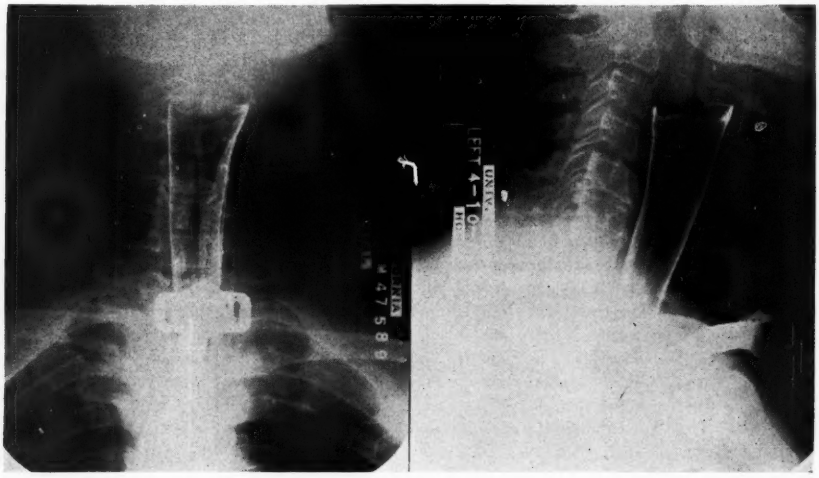

Fig. 9.—The tantalum mesh is shaped to approximate the diameters of the hypopharynx and esophagus. The adequate caliber of the tube is evident.

Recently, the use of splints of various sorts has been proposed to bridge the defect between the hypopharynx and esophagus. We have used prostheses in two patients.* A skin graft of intermediate thickness wrapped about a tantalum gauze mesh splint as suggested by Edgerton[2] was used in both instances. The first patient developed a small salivary fistula that healed within five weeks after surgery. He is now able to tolerate soft foods without difficulty (Fig. 9). The second patient's recovery has been complicated by a rather large fistula at the level of the esophageal anastomosis that persists one month after surgery.

CONCLUSION

With respect to the far-advanced malignant lesions for which this extensive operation is performed, the results are not particularly discouraging. It is

*Dr. M. Galante, Chief Resident in Surgery, performed these two operations.

reasonable to assume that if the principle of wide en bloc excision is applied to earlier, more localized lesions, the results of surgical treatment will be significantly improved.

As surgery of this magnitude develops to an even greater security, and better results can be expected with increasing frequency, the wider application of extensive surgery for earlier lesions in and about the hypopharynx must be accepted.

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DISCUSSION

DR. MARK M. RAVITCH, Baltimore.—There are a couple of points of interest in connection with Dr. Grimes' paper and his description of the Wookey procedure. It may be of interest to the members of the Association that in 1891 Von Hacker performed a Wookey procedure quite successfully on dogs and advised its performance on human beings, and, in 1908, reporting in the *Archiv. f. Klinische Chirurgie*, Vol. 87, he performed a full-fledged Wookey operation with a square flap laid down as so well described today. That patient was alive and well sixteen months later. Dr. Grimes mentioned Dr. Edgerton's cases; he has now had a considerable experience with replacement of the pharynx and upper esophagus by the tantalum mesh tube which you saw pictured, which is the method of course of Mr. Price Thomas' compatriots, Robb and Bateman, which has been employed for both the esophagus and the trachea. As Dr. Grimes indicates, when that method is successful, the patients are very rapidly rehabilitated.

DR. H. BRODIE STEPHENS, San Francisco.—Dr. Grimes is to be congratulated upon his excellent presentation of our results in the application of the Wookey operation in the management of carcinoma involving the cervical segment of the esophagus. Dr. Grimes has demonstrated the utilization of unilateral radical neck dissection in combination with the Wookey procedure.

We all admit that carcinoma in this area presents many problems with regard to surgical treatment and, in addition, in our experience the larynx usually has to be sacrificed. Local recurrence rate is high, and the result is a low salvage rate. On the other hand, we believe we are obliged to offer these unfortunate victims some ray of hope and some relief, if possible. Metastatic cervical lymph node deposits, if unilateral, have not been considered a contraindication to operation.

The recent procedure described by Edgerton,* namely, a one-stage reconstruction of the cervical esophagus in which the cervical esophagus is replaced by a split thickness skin graft molded over a stainless steel wire mesh fashioned into the shape of the removed segment of the esophagus, may become a distinct advance over the two-stage operation presented today by Dr. Grimes.

We have had occasion to operate upon two patients employing the technique described by Edgerton. It was necessary to remove the wire mesh three months following insertion in one patient because of induration and low-grade inflammatory reaction in the neck. The other patient is tolerating the wire prosthesis satisfactorily for a period of two and one-half months. Whether or not a stricture will develop following removal of the wire stent will have to be determined by future observation.

In closing, I should like to encourage the members of our Association, particularly the younger ones, to continue their efforts in the development and improvement of the treatment of carcinoma in the cervical portion of the esophagus.

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*Edgerton, E. G.: Surgery **31**: 239-250, 1952.

CARCINOMA OF THE ESOPHAGUS

A Consideration of Curative and Palliative Procedures

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THE gloomy predictions of a few decades ago that esophageal cancer could not be expected to yield to surgical attack have proved short sighted and unsound. Such predictions are epitomized in the statement, "Because of the anatomic structure and relationships of the esophagus, the highly malignant carcinomas of the organ, the frequent occurrence of metastasis, the danger of fatal infection, and the mutilation which must always cause great shock, surgical removal of these tumors cannot be expected to be attended with any degree of success."[1] This pessimism has proved in error so far as it pertains to the actual technique of resection. Despite the fact that most patients with esophageal carcinoma are elderly, and generally debilitated, the operative mortality of esophageal resection, though appreciable, is no longer forbidding.[2]

The distressing fact is that the increased facility in thoracic surgery and all of the adjuvants available today have changed the picture of esophageal cancer only for the immediate postoperative period. The survival rate beyond a few months is still miserably poor, and cures at any given clinic are spoken of in terms of individual cases and scarcely in terms of percentages. Sweet[2] reports one five-year survival of 30 patients with resected carcinomas of the mid thoracic esophagus and Parker and associates[3] report a group of 117 cases of esophageal cancer of whom only 2 patients were still living, both less than one year after operation. At the Johns Hopkins Hospital there have been no five-year cures.

We are accustomed to emphasize to medical students that cancer is not primarily a mechanical disease and that its rational treatment properly should not be mechanical, i.e., surgical. Yet up to some point in the life of every cancer it is possible to cure the patient by excising the primary tumor with surrounding tissues. In today's stage of surgical virtuosity almost any viscus or combination of viscera can be successfully removed, if a few primary organs are left behind. However, surgeons tend to lose sight of the puerility of the concept of surgical treatment for cancer, and continue to devise more and more extensive operations for more and more hopeless lesions.

We propose an inventory of the present situation in cancer of the esophagus and an assessment of the results in an attempt to determine what should be the surgeon's orientation.

The posterior mediastinum can be compared to a conduit containing a number of axially directed structures closely apposed, and sharing lymphatic trunks

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and nodes. The esophagus lies in close relationship to the trachea, aortic arch, left bronchus, pericardium, descending aorta, diaphragm, and both mediastinal pleurae.

A cross section of the mediastinum of a full term infant (Fig. 1) gives one some idea of the hopelessly intimate relationship of the esophagus with other structures.

The lymphatic drainage of the esophagus is both cephalad and caudad (Fig. 2). Cephalad the drainage is to the bronchial and tracheo-bronchial nodes to nodes, anterior to the aortic arch, and to nodes in the hollow of the arch.

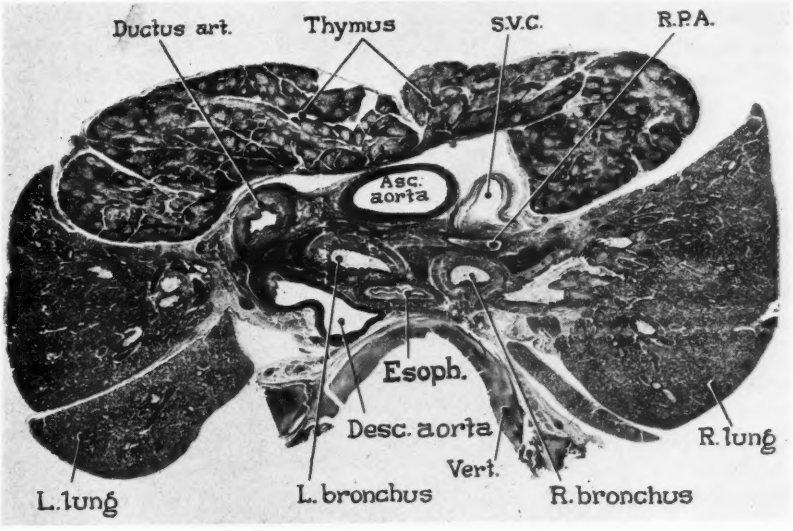


Fig. 1.—Cross section of thoracic viscera and vertebra of full-term, stillborn infant, superior view. (Prepared by Dr. J. R. Williams and Mr. Edw. Walker.) The section has been made just below the level of the bifurcation of the trachea. The extreme intimacy of the anatomical relationships of the esophagus is well shown. The esophagus nestles between aorta and left bronchus, is almost equally close to the right bronchus, and lies immediately upon the vertebra. With growth of the body, the closeness of apposition scarcely changes and one readily sees how impossible a feat is a "radical" resection of the esophagus. Of interest is the thick walled, muscular, still patent ductus arteriosus.

There are wide intercommunications between these several groups of nodes and with those draining the parietal pleura. Caudad the flow is to the nodes at the esophago-cardiac junction and the associated anastomotic pathways. Resection of the lymphatics would therefore require en bloc removal of both mediastinal pleurae, nodes along both sides of the trachea and at the bifurcation, and those behind and in front of the aorta—a manifest impossibility.

The nature of the esophagus and its neighboring structures is such that nowhere, except perhaps at its ends, is it feasible to perform a block dissection taking a reasonably wide mass of tissue in all directions. One can indeed expect that simultaneous resections of trachea or bronchi will shortly be more readily performed than they are at present but even this is likely to be

in the nature of surgical gymnastics rather than a real advance in therapy with wide applicability. In desperate situations in the surgery of cancer it is customary to advocate more extensive operations. With the esophagus this can partially be accomplished by extending the length of the cylinder of re-

Fig. 2.—The lymphatics of the posterior mediastinum from the "Vasorum Lymphaticorum Corporis Humani, Historia et Ichnographia" of Paulo Mascagni, published in 1787. More modern anatomical studies appear to have added little. Note the extensive communications of the bronchial, tracheobronchial, tracheal and paratracheal nodes with those of the esophagus, those anterior to the aortic arch and those in the hollow of the arch as well as the caudal pathways to the diaphragm and gastric cardia. Not shown are the nodes in the pleura and posterior parietes. Observe again the hopelessly disadvantageous position of the esophagus.

section. However, the diameter of the resected cylinder cannot be increased as long as one must leave behind other, closely associated, axially directed structures.

It might still be possible to cure cancer of the esophagus surgically, in spite of these facts, if it could be diagnosed early in its life history. But gloomy reports attest to the bland insidiousness and deceptive innocence of

the early symptoms, or the complete absence of any symptoms before even gross inoperability may be manifest. In addition esophageal cancer metastasizes early to the lymph nodes both cephalad and caudad. Furthermore, distant metastases are not uncommon. Possibly on this account patients with small, movable, presumably early lesions are as likely to die of recurrence as are those patients with longer histories and larger tumors.

Thus, the evidence of the anatomical relationships of the esophagus which enforce a cylindrical resection, the mode of lymphatic spread which is outside the cylinder and the difficulty in obtaining patients early in the disease lead to the expectation that the curability of this disease will be low.

Actually Sweet[2] reports only one patient alive of 30 in whom the midthoracic esophagus was resected 5 or more years before. His results are somewhat better for carcinoma of the lower esophagus and cardia. Resano[4] lists one 5 year and one 6 year survival of 1,000 patients treated on the service of Finochietto. Numerous similar reports of smaller series could be cited. Although direct operative attack offers one of the best methods of palliation it is associated with a greater mortality rate than less sizable procedures and gives little more prospect of cure. This method, then, leaves something to be desired, and it is proper to consider the alternatives.

There is no need to review the dismal story of the improperly named palliative gastrostomy which has justly been generally abandoned.[5, 6] No form of therapy is adequate which does not rapidly restore deglutition.

In special cases—desperately debilitated patients, patients with severe cardiac or other complicating lesions—no type of operative procedure may be feasible. In these, palliation can be achieved in one of three ways. Simple bouginage will often permit a patient to swallow fairly well for weeks at a time and can be performed repeatedly, but obviously without any influence on the outcome.

The Souttar tube,[7] the use of which originated when the operation was almost invariably fatal, still has its place as Allison and Borrie[8] have reminded us. We have occasionally employed a plastic variant which is forced into the malignant stricture by pressure on a removable obturator. In one instance when thoracotomy revealed an inoperable lesion the tube was passed while the chest was open. This proved to be our most successful use of this type of indwelling tube. There was immediate restoration of deglutition and relief of the obstruction until death a few months later.

A third nonoperative method of palliation offers considerably greater therapeutic possibilities. Irradiation for cancer of the esophagus can be administered by radium bougie, by direct implantation of radio active material, or by deep roentgen irradiation of various voltages. The most important initial observation in the course of the radiation therapy of cancer of the esophagus is the usual rapid relief of dysphagia.[9-10] In the majority of cases the patient is able to swallow for the duration of his course even if he dies of his disease.

Deep x-ray therapy, like operative extirpation, has not appeared to affect the outcome of the disease seriously except for individual instances of long-term survivals. The radium bougie and the local implantation of radioactive material have in general not given as good results as has deep x-ray therapy. In a review of over 800 patients treated by irradiation, Fleming[9] found that 83 per cent died within a year and that only 10 patients survived more than five years, one of these ultimately dying of metastasis. The results of the theoretically superior rotation treatment appear to be comparable.[11]

Of great importance is the observation that after irradiation of esophageal cancer some deaths occur from perforation into the mediastinum, pleura, or aorta and at autopsy no residual tumor is found. This suggests the possibility that if before irradiation the esophagus were removed or rendered empty and clean by short circuiting, such deaths might be obviated. In this connection a case has been reported by Lincoln Brown[12] in which at operation a silver tube was passed into the esophagus and a 5,000 roentgen tumor dose of x-ray subsequently administered. No tumor was demonstrable endoscopically 6 months later.

When cancer of the esophagus occurs in a patient who is a reasonable candidate for operation, circumstances may indicate one of several procedures.

It has been demonstrated that the stomach can be mobilized so as to permit a primary anastomosis to any level of the esophagus, even well into the neck. However this procedure is a considerable task, requiring extensive dissection and for the high tumors a difficult anastomosis. On the other hand for tumors of the esophagus in the lower fourth, resection and esophagogastrostomy is to be recommended when the tumor is resectable. If a low esophageal carcinoma or carcinoma of the gastric cardia cannot be resected the obstruction may be by-passed by dividing the esophagus, closing the lower end and connecting the upper end to a Roux-Y jejunal loop. Only one or two jejunal vessels need be sacrificed to prepare such a loop, its circulatory adequacy need not be a cause for concern, and the operation is readily performed.

In the higher tumors there is some reason to doubt the advisability of elevating the stomach. In addition to the technical hazard of the high anastomosis there is the disadvantage of the presence of a distensible stomach in the thorax. Regurgitation of gastric juice into the pharynx is often a source of distress with the added hazard of aspiration. The risks of an intrathoracic anastomosis of a very long jejunal loop seem unjustified,[15] but an antethoracic Roux-Y loop can be mobilized with much less difficulty than that attendant upon mobilization of the stomach and with little more risk to life than that inherent in a small bowel anastomosis.

In the day of the Torek procedure, numerous attempts and some successes were recorded in reconstructive antethoracic esophagoplasty. Stomach, jejunum, and colon were all employed as well as the several varieties of epidermal tubes and combinations of skin and intestinal tubes. This frequently entailed a multiplicity of procedures requiring many months. As a result ante-

thoracic esophagoplasty was held inapplicable to the problem of reconstruction after resection of cancer of the esophagus with the anticipated relatively brief survival. This attitude can be revised now in the light of greater experience with esophagoplasty as demonstrated by the work of Yudin.[16] Greater familiarity with the technique has reduced it to a two-stage operation with a delay of only a few days between stages.

The operation reported by Roux[17] in 1907 for constructing an antethoracic esophagus of jejunum is the method of choice in antethoracic esophagoplasty. In most patients the jejunum can be brought above the clavicle and anastomosed to the esophagus a few days later. It is wiser, rather than to risk a slough, not to attempt to pull the jejunum higher than it will go readily. In two of our cases resection of the medial end of the clavicle permitted tension free anastomosis of jejunal tube and esophagus. Three, and at times four, principal jejunal vessels may be divided to provide a long Roux-Y jejunal loop. All serosa is excised from both sides of the mesentery of the loop which is brought through the mesocolon and subcutaneously. A wide subcutaneous tunnel is made from the xiphoid to the neck and the bowel is then gently pushed and drawn through it. A temporary feeding gastrostomy is constructed. Anastomosis with the esophagus is accomplished several days later. Roux anastomosed the lower end of his jejunal loop to the stomach. Two experiences in young adults who developed peptic jejunal ulceration have led us to distrust this step. There has been recurrent discussion of the advisability of the use of an antiperistaltic jejunal loop which is thought by some to be easier to raise[18, 19] although the published experiences have been unsatisfactory.

There are many patients who will tolerate a Torek procedure but who would not be likely to survive the additional strain of mobilization of the stomach and the interference with pulmonary function caused by placing the stomach in the chest. Antethoracic esophagoplasty may be performed as soon as such a patient is well over his thoracotomy and he may be expected to be taking his food orally within another two weeks. Small fistulae at the site of the cervical anastomosis are not rare, but usually close spontaneously.

This therapeutic approach has the following advantages.

1. There is no tendency to compromise in the amount of esophagus resected and whatever virtue resides in resection is reserved to the patient.
2. The major intrathoracic procedure is short and relatively simple.
3. The anastomosis is extrathoracic and a relatively innocent procedure as far as concerns risk to the patient or effect upon his general condition.

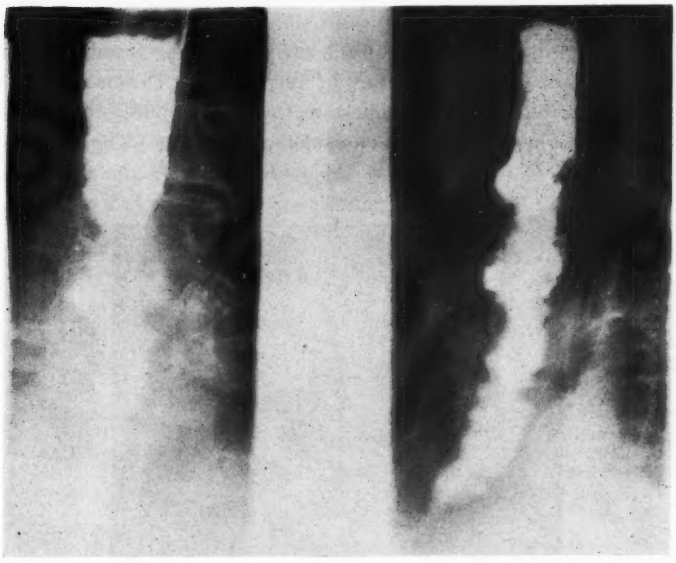
There is an appreciable risk in elderly, arteriosclerotic patients, of losing a portion of the oral end of the jejunal loop if it is made long enough to reach the cervical esophagus. When an antethoracic shunt is employed a portion of the tube may slough in the subcutaneous tissues, as in two of our patients, without causing any major distress. One patient, with desperate coronary disease, succumbed before the esophagus could be completed but the Roux-Y loop offered him a satisfactory leak-proof feeding jejunostomy. In the other

patient the antethoracic esophagus was ignored after the proximal end sloughed. The inoperable tumor was partly resected and esophageal continuity successfully restored by use of a plastic tube (vide infra). It may be impossible, in adults, with sclerotic vessels and thick fat mesenteries, to raise loops to the neck as often as in children. However, as in Roux' own case, the cervical esophagostomy may be connected to the antethoracic jejunostomy by a skin tube. Such a skin tube is fashioned and anastomosed in a single stage. If the skin of the chest wall is particularly lax the tube made of the thoracic skin may be covered by loose skin drawn from the sides. If such skin is not available the tube may be covered with a free-split thickness graft. The tube itself is so fashioned as to include and enclose, at upper and lower ends, the esophagostomy and jejunostomy.

In 1922 Neuhof and Ziegler[20] experimented in dogs with the use of rubber tubes as replacements for esophageal segments. In animals they were regularly successful with a two-stage operation. In the first stage the esophagus was packed off to produce granulation tissue and seal off the mediastinum. In the second stage the esophagus was resected and a rubber tube tied into the upper and lower segments. The tube usually passed after a time and the resultant esophagus was found to be lined by normal appearing mucosa, to be strong and smooth, and to show no tendency to obliterative cicatrization.

In dogs, with their thin pleura, Neuhof was obliged to work with the cervical esophagus but felt that in patients the two-stage operation could be applied to the thoracic esophagus approached extrapleurally through the posterior mediastinum. Berman of the Sinai Hospital, Baltimore, has developed a method for replacement of the thoracic esophagus with a plastic tube. First in experimental animals[21] and then in a series of patients he demonstrated the feasibility and simplicity of his method. The desired length of esophagus is resected, a large calibre flexible, flanged Polythene tube is sewn into the upper and lower ends and tied in place, the mediastinal tissues being then closed about the tube. In our clinic five such operations have been performed by four surgeons. In four instances the operation was performed without difficulty and the patient subsequently swallowed well, though in one patient the tumor was grossly inoperable and cancerous tissue was left on the aorta. One is still in the hospital gravely ill, but able to swallow well. All of these patients were operated upon through the right side of the chest. In a fifth patient, operation was performed through the left chest and the tube placed anterior to the aortic arch with fatal outcome.

Although one may have an a priori objection to the use of buried prosthetics in surgery, it would appear that, in this instance, the tube acts only as a stent about which fibrin forms an impermeable sheath which is then lined by esophageal mucosa growing in from either end. Barium swallowed a week after operation passes through the lumen of the tube and may pass partly between the outside of the tube and the encasing mediastinal tissues. Although Berman has employed tubes of considerable length there has appeared in practice an understandable tendency to skimp on the length of



A.

B.

Fig. 3.—G. W. This was a 74-year-old man with a three month history of dysphagia and weight loss. There was a squamous carcinoma of the middle third of the esophagus. Because of his age, extreme emaciation and of debility and the apparent extensiveness of the tumor, an ante-thoracic esophagoplasty was performed,—the first stage, 12-31-52, the second, 1-12-52. He is alive and comfortable four months later, has maintained his weight and takes a semisolid diet without difficulty. *A*, Roentgenogram showing the obstruction and irregularity of the esophagus. *B*, The antethoracic jejunal loop.

esophagus resected in order to make the use of the tube feasible, particularly when the carcinoma is near the apex of the pleura. The use of this plastic tube provides the quickest and easiest method of esophageal reconstruction and simplifies the operative attack on esophageal cancer. The use of the tube is most applicable to carcinomas of the mid portion of the esophagus.

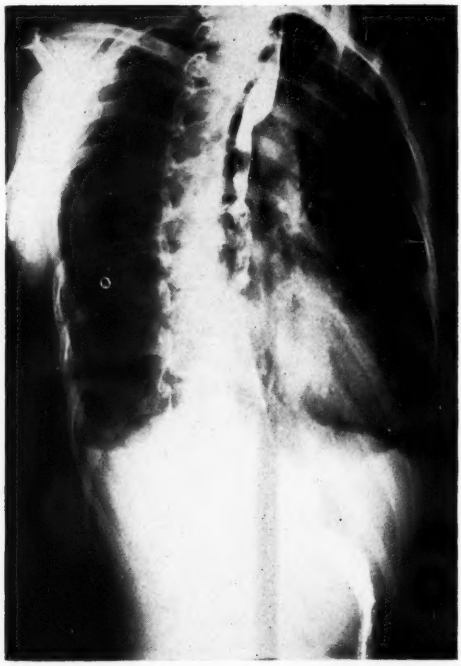


Fig. 4.—C. C. Postoperative roentgenogram of a 37-year-old woman operated upon April 14, 1952, by Dr. William F. Rienhoff, Jr. A carcinoma of the middle third of the esophagus was resected and the defect bridged with a polythene tube which extended from the arch of the aorta to the diaphragm. The x-ray shows barium and air in the plastic tube.

SUMMARY

The results of the operative treatment of carcinoma of the esophagus are disappointing in terms of survival and of cure rates. The organ is fundamentally so situated, and the disease of such a character, as rarely to lend itself to cure by operative means. It seems justifiable therefore to direct our efforts toward palliation rather than cure and to seek the methods which will yield the best return in terms of patient months of comfort, with deglutition restored.

In manifestly incurable tumors swallowing may be restored by irradiation, or by a shunting procedure, preferably antethoracic esophagoplasty. In cancer of the lower fourth of the esophagus resection and esophagogastrostomy is the treatment of choice for resectable lesions and an intra thoracic shunt with a

Roux-Y jejunal loop the treatment of choice for inoperable lesions. In the mid esophagus three operative procedures are available for resectable tumors each with its own advantages:

1. Resection and esophagogastrostomy
2. Resection and antethoracic esophagoplasty
3. Resection and plastic tube reconstruction.

For nonresectable tumors and in debilitated patients antethoracic esophagoplasty may be offered with supplemental irradiation.

Lesions near the apex of the thorax are best treated by antethoracic esophagoplasty with or without resection or irradiation.

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DISCUSSION

DR. J. E. MAC MANUS, Buffalo.—We have had some experience with Dr. Berman's method of palliative surgery in the upper third of the esophagus. Our series numbers five cases. We have had no immediate postoperative mortality. I thought you might like to

see a specimen. This patient lived four months after surgery. We have this post-mortem specimen; and I would also like to show a cineradiographic picture demonstrating the method of passage of food through this type of prosthesis.

(Slide.) This demonstrates the pathology in this case. The operation is not prolonged, not difficult, and even patients who are poor risks will tolerate it rather well.

(Slide.) This is the polythene tube lying in the mediastinum with the distal and proximal part in view, and the lower end of the tube. The picture was taken approximately three weeks postoperatively. There is some lipiodol which he is not able to force through this opening that escaped down into the trachea.

(Slide.) This picture was taken after the dye had gone down, and some of it has become adherent to the polythene tube.

(Slide.) This is the specimen four months after surgery. There is a solid tube of carcinoma and fibrous tissue, very tough and hard, surrounding the polythene tube. The patient was swallowing a liquefied and soft diet satisfactorily.

(Movie.) This is a cineradiographic picture taken of this man six months after operation. It runs a circle, keeps repeating itself about every eight seconds, so that you have to watch it more or less as you would a football game; first the left end then the center next, etc. Otherwise, if you try to look at it all at one time you miss a good deal of the detail. As you watch this you see the barium coming down in and around the tube as well as through the tube.

DR. LYMAN A. BREWER, III, Los Angeles.—We have had disappointing experiences in curing carcinoma of the esophagus similar to those presented by Dr. Ravitch. The forms of palliation which were so nicely shown by the speaker have an important place in treating definitely inoperable carcinoma of the esophagus. It is regrettable that the majority of the cases seen by surgeons today fall into this category. However, since surgical resection of the esophagus is curative when the cancer is confined to the esophagus, we strongly believe that more strenuous attempts should be made to diagnose the carcinoma in the early, resectable stage. The high mortality is linked with operations on advanced cases in most instances. Unfortunately, the textbooks of medicine generally present only advanced findings for the diagnosis of carcinoma of the esophagus, and the important early signs and symptoms are usually not mentioned.

The early symptoms are those of mild discomfort, soreness, or tightness in the thorax or upper abdomen. If the esophagus is considered, along with the lungs and heart, as a possible cause of these mild symptoms, then the early cancer will not be overlooked. It cannot be stressed too much that *at first the dysphagia is not progressive.* There are times in the early stage of the cancer when, for various reasons, the patient swallows better. The carcinoma acts somewhat as a foreign body, with resultant associated esophagospasm. When the esophagospasm associated with an early carcinoma of the esophagus is relieved by belladonna preparations, then both the physician and the patient are lulled into a sense of false security by the belladonna response. At least one-third of our cases have shown this. Sloughing of the tumor will also permit the patient to swallow better for a while. The frequency of reference of symptoms caused by carcinoma of the esophagus to the abdomen focuses the attention of both physician and patient upon abdominal disease. Most often a careful study of the stomach and intestines is made, and examination of the esophagus is overlooked. We have had a number of cases in which the proper diagnosis could have been made readily from six months to one year earlier by thorough esophageal study when the symptoms were primarily epigastric in nature. Furthermore, the cancer of the lower esophagus that arises in the cardia of the stomach presents diagnostic problems. Since this type of carcinoma spreads to the esophagus in the muscularis and submucosal layers, the mucosa shows no tumor or ulcer. However, if an organic stricture of the esophagus is present at the cardia, or there is an inelastic infiltrated muscularis, then this patient should be explored.

It is certainly the duty of the thoracic surgeons to teach the pitfalls in the early diagnosis of cancer of the esophagus and, in the future, we will have many more cures to

report. We have been told that the original case of esophageal resection for carcinoma of the esophagus with esophagogastrostomy, performed by Adams and Phemister in this country in 1938, is still alive. The long-time survival of this one patient should spur us all to teach the early diagnosis of carcinoma of the esophagus.

DR. OWEN H. WANGENSTEEN, Minneapolis.—I can sympathize with Dr. Ravitch in his statements concerning the difficulties of esophageal cancer surgery. It is now almost ten years since Ohsawa in Kyoto, Japan, first announced the successful re-establishment of continuity after excision of cancers of the fundus and cancer of the lower esophagus. It seems a bit strange that after all these years we have not done better. The only five-year results that have been published to date are those of Richard Sweet, and, as he said in his recent article in *Surg., Gynec. & Obst.* (**94**: 46, 1952), the results of surgery for cancer of the mid- and upper esophagus have been so poor that he hesitated to record them. However, you will recall that in his operations for cancer of the lower esophagus and the fundic end of the stomach, with patients not having lymph node involvement, 40 per cent of the patients were alive after five years. The tragedy is, of course, that so many do have lymph node involvement; as I recall it, his figures for those having lymph node involvement showed five-year survival in 15 per cent of the patients.

Julius Caesar propounded an old military maxim when he said, "Divide and conquer." This is true in military as well as in surgical matters, and I am not referring primarily to staged procedures—on the contrary, I am referring to dissection of the problem. I too have suffered from the experience of losing patients for no obviously good reason following excision of cancer of the mid- and upper thoracic esophagus. Sometimes the loss of the patient is very difficult to understand, there being at autopsy scarcely anything to account for the lethal outcome. The most common finding appears to be atelectasis. In thinking this over, two thoughts occurred to me. Shortening the path of the migrated stomach permits excision of a greater length of esophagus on the proximal side of the lesion. This is certainly an important objective in curing cancer of the esophagus. It is desirable to excise five to seven centimeters above the cancer. The shortest path for the migrated stomach is through the right diaphragm, anterior to the left lobe of the liver and anterior to the pulmonary root—that is, anterior to the lung. This path seems to be several centimeters shorter than the conventional path through the hiatus and posterior to the lung root.

But what causes the atelectasis observed in these patients? Well, mismanagement of the fluid problem can do it, by inviting overhydration. However, I think the main thing is regurgitation into the pharynx and the larynx from a very short residual esophagus. One thing which I have done latterly which has made some difference in patients recently operated upon is to leave the inlying intratracheal tube in place until the patient is very much awake. In the meanwhile, in the recovery room, the nurse aspirates the pharynx and mouth until both are quite dry. Then, when the patient wakes up, the cough reflex will lessen materially the chance of aspirating mouth or gastroesophageal secretions into the trachea. The other expedient which I have come to employ, and which I believe has some bearing on the occurrence of atelectasis is placement of a No. 14 French 4-hole duodenal tube into the jejunum at the jejunoduodenal angle. This tube is threaded backward into the thoracically migrated gastric pouch. This catheter can be left in situ well into the convalescent period. And, obviously, the application of suction to this tube lessens considerably the opportunity for reflux of gastric juice or bile into the trachea. A No. 14 French 4-hole duodenal tube is also threaded into the gastric pouch from above by the anesthetist when the esophagogastric anastomosis has been completed. This tube need only remain in a few days.

Keeping the trachea dry during the waking-up period, by retaining the intratracheal tube in place until the patient is fully awake, and the avoidance of reflux into the trachea from the stomach during convalescence—these two expedients, I believe, will be found very helpful in lessening the operative mortality attending excision of cancers in the mid- or upper esophagus.

The spread of cancer in the esophagus is largely up and down the reaches of that organ. It is very important, therefore, to excise long lengths both above and below; most

of us having compromised too much on the excision above the cancer, being satisfied with a margin of a centimeter or two. This is not enough. For cancers in the lower esophagus, I have come to divide the azygos vein, anastomosing above it, routinely. I have seen no suggestion that placement of the stomach in front of the lung invites atelectasis.

Placement of water-filled rubber balloons on top of the pulmonary root in dogs, that walk on all fours, does not invite atelectasis. The factors hedging about the item of aspiration certainly are far more important.

In patients under 50 years of age with an active gastric secretion having an esophageal cancer, I am not certain that the stomach is the best replacement organ for the esophagus. The only good thing to say for it is that it is readily available. In such instances, the colon is probably a far better organ, though the technical difficulites in employing it rather than the stomach are obvious. In patients with an active gastric secretion, any extra length of stomach, not needed at the upper end, should be excised. The observations of Demel (*Langenbeck's Archiv.* **128:** 453, 1924) have important connotations for resection of this segment of the esophagus for cancer, suggesting that the mid- and upper thoracic esophagus do not have as rich an arterial blood supply as the cervical and terminal esophagus.

Whereas there may be an occasional indication for the type of procedure which Dr. Ravitch has outlined, I would like to suggest that it is too early to capitulate to palliative procedures. We must continue our dissection of, and our attack upon the problem. If we can learn to master the intricate technical considerations and the potential physiologic hazards which hedge about the situation, after excision of long lengths of the esophagus, the initial operative mortality will be far less formidable. Such has been the history of all operations. And, if greater lengths of the esophagus are sacrificed, the number of ultimate cures will also be greater. X-ray irradiation is still not a strong competitor for the high thoracic-lying esophageal cancer. Continuance of efforts at surgical cure is therefore still in order, even though the risks are large and the present cure rates are low.

DR. OSLER ABBOTT, Atlanta.—I am sure that the factors mentioned by Dr. Wangensteen are of utmost importance. There is a contribution which my associate, Dr. William Hopkins, has made in the last few years which is in the process of being presented. I think this work designates his understanding and appreciation of the physiologic disturbance of transection of the diaphragm. I think that is of major importance. The anatomic distribution of the phrenic nerve, as it comes across from its point of insertion anteriorly and medially, must not be interrupted in order to maintain the optimal function and maximal activity of the diaphragm postoperatively. Therefore, Dr. Hopkins recommends that the diaphragm be incised circumferentially about 2 to 3 mm. inward from its costal attachments. This gives a remarkable access to the abdominal contents. Furthermore, if the pathologic process does not require excision of the area of the hiatus, the hiatus and the crus muscles, so intimately appreciated by Dr. Alison, are maintained intact. This preservation of diaphragmatic function, both for respiratory processes and for the pet-cock action of the crus muscles, is of distinct value in preventing unnecessary postoperative debility and complications. It emphasizes that physiologic considerations in major and so-called minor surgical details are the prophylaxis in regard to postoperative discomforts.

DR. ROSS ROBERTSON, Vancouver, B. C.—I agree in part with Dr. Ravitch and Dr. Wangensteen, but instead of taking Dr. Ravitch's high road beneath the skin, or Dr. Wangensteen's low road through the left chest, I choose to take the middle road through the anterior mediastinum, through which to bring the Roux Y-tube. Since reporting on reconstruction of the esophagus here two years ago, we have had eight additional cases of reconstruction for carcinoma of the esophagus. Two of these patients died postoperatively. One was a man aged 77 years, the other man was riddled with secondary tumor. Three others are still alive, two to ten months after operation. The remaining three survived from seven to twelve months after operation.

Of the survivals, all were able to swallow quite readily and with considerable satisfaction postoperatively. I have come to the conclusion that probably the way to treat car-

cinoma of the esophagus may be summarized as follows: If a carcinoma in the lower quarter of the esophagus is squamous-cell carcinoma not arising in the stomach, I think Dr. Sweet's method is preferable; that you have an opportunity of resecting the entire carcinoma and not getting recurrence at the anastomosis. In all other carcinomas of the esophagus the Roux Y-tube should be prepared, brought up through the anterior mediastinum, and the patient enabled to swallow with comfort.

Then, if one feels that the tumor may be resectable, he may go back two or three weeks later through the right chest and remove the entire esophagus for several centimeters on each side of the tumor, or the entire stomach if necessary and all the surrounding lymph nodes.

DR. JOHN H. GIBBON, JR., Philadelphia. It seems to me that this Association has seen in the last couple of years a tendency toward backing away from attempts at radical cure of carcinoma because of a rather forbidding mortality. Some of us had a discussion the other night about the same subject relative to carcinoma of the lung. It seems to me that there is another attitude to take, that is, to continue with an aggressive attitude in the attempt to eradicate the disease, and to devote our efforts toward trying to find out the cause of these unexplained deaths that Dr. Wangensteen mentioned. I appreciated very much Dr. Ravitch's philosophical and historical discussion, but I must differ with him in my attitude toward the philosophy. I am about to reverse what I said three years ago before this Association. About nine months ago Dr. Allbritten, Dr. Templeton, and myself decided that we would reverse ourselves about the left-sided approach and use a right thoracotomy for esophageal lesions at the level of, or cephalad to, the aortic arch. We hoped to lower the mortality in the higher esophageal lesions, which is the real crux of the problem. In the past nine months we have operated upon five patients with esophageal lesions at the level of the arch or in the neck, with one death, using a right thoracotomy.

I would particularly like to advocate the use of two operating teams for lesions of the cervical esophagus or the thoracic inlet. With two operating teams, you can cut the operating time in half. One team mobilizes the stomach in the abdomen while the other team mobilizes the cervical esophagus and performs when indicated a radical neck dissection with, if necessary, a hemithyroidectomy or laryngectomy. Then, with the patient still in the supine position, the right chest is opened by the team operating in the neck. The thoracic esophagus is mobilized and the abdominal operating team passes the stomach up into the thorax. The other operating team passes the stomach into the neck and performs the esophagogastrostomy there, while the abdominal team closes the abdominal and thoracic incisions.

I think we should devote still more time to the aggressive attack on these lesions with an attempt to reduce the mortality, rather than to throw up our hands and say that this lesion is beyond us. We have recently reviewed our results in 148 patients with cancer of the esophagus or of the gastric cardia. This is a consecutive series seen in the past six years. The lesion was resected and an anastomosis performed in 93 of these patients. From this series we can add to Dr. Ravitch's five-year survivals one case. Of course the majority of our 148 cases have been seen in recent years, not five or six years ago. In conclusion, I would make a plea that we continue our efforts toward reducing mortality and keep up an aggressive attack upon the disease.

DR. RAVITCH (Closing).—Dr. MacManus mentioned his use of the Berman tube with draining of the mediastinum. Dr. Berman tells me it is not necessary to drain the mediastinum. None of the cases at Baltimore, of which there have been 19 at various hospitals, 12 of them Dr. Berman's own, have had the mediastinum drained and of the 19, there has been only a single fistula to date.

I should have been very disappointed if Dr. Wangensteen and Dr. Gibbon had not disagreed with a fair amount of vigor. I think perhaps we will have to go back a little farther than Julius Caesar to the architect who placed the esophagus in such an awkward position for the surgeon. Dr. Robertson is a little bolder than we are. I am sure that the jejunum is the organ to bring up anywhere above the lower portion of the esophagus. We just have not had quite the courage of our convictions about bringing it up either

intrathoracically or mediastinally. We have had experience with two patients in whom there was a subcutaneous slough. One is a man who has had many attacks of coronary disease, and he sloughed off several inches of the antethoracic esophagus. It left him a beautiful feeding jejunostomy as a result which should not leak at all, and, incidentally, one of the things a Roux loop will give is a beautiful feeding jejunostomy anywhere, without leakage. The other patient had a slough of the entire antethoracic loop, to the costal margin, was not sick at all, and his surgeon elected then to resect the tumor and place the plastic tube in situ, although he had to carve the tumor from the bronchus and the aorta. He got by in that instance.

I would like to say again that while we do not class ourselves as among the timid group of surgeons, the point is that the esophagus is not like the breast which is virtually a skin appendage, practically off the body, and one can do a well-conceived cancer operation there. It is just not possible to take out the esophagus that way.

BRONCHIOGENIC CARCINOMA, A PRODUCT OF MULTIPLE SITES OF ORIGIN

EDWARD J. MCGRATH, M.D., EDWARD A. GALL, M.D. (BY INVITATION), AND DALE P. KESSLER, M.D. (BY INVITATION)
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A LARGE segment of opinion has long held to the principle of the unicellular or unicentric origin of neoplasm. Under the influence of Cohnheim,[1] Mallory,[2] McFarland,[3] and Kettle,[4] to mention only a few, this hypothesis has been widely accepted. Others, however, have from time to time disputed its validity. In recent years Willis[5] has gathered a formidable body of evidence indicating the origin of tumors from multiple sites and has, himself,[6, 7] provided convincing data supporting the earlier work of Lohmer[8] in relation to tumors of the lip and skin. Many similar observations[9-17] have served to support the principle of the multicentric origin of neoplasm in other areas.

Save for the diffuse form of so-called alveolar-cell carcinoma, however, little attention has been directed to this phenomenon in the case of pulmonary neoplasm. Isolated case reports have cited instances of multiple gross and microscopic primary carcinoma in lungs[18-22] but only in the meticulous study carried out by Lindberg[23, 24] has there been evidence of a more than sporadic incidence. One suspects that failure to observe this phenomenon as a common one may be attributed in large part to the custom of relying upon sections from small blocks of tissue removed directly from the presenting tumor and from obviously invaded lymph nodes. The possibilities inherent in the study of bronchiogenic carcinoma through the medium of large tissue sections were beautifully demonstrated before this Association in 1949 by Phillips, Adams, and their associates.[25, 26]

Since 1947, the Departments of Surgery and Pathology at the University of Cincinnati have been engaged in a series of studies utilizing such large sections. A recent investigation of carcinoma of the stomach[27-29] by this means revealed an unsuspected frequency of multiple neoplastic zones and stimulated our interest in applying this technique to bronchiogenic carcinoma.

MATERIAL AND METHODS

Over 100 gross specimens of lung were processed from a number of hospitals in the Greater Cincinnati area.* Of this group 94 contained neoplasm.

From the Departments of Surgery and Pathology, College of Medicine, University of Cincinnati and the Cincinnati General Hospital.

This investigation was supported in part by a research grant from the National Cancer Institute, National Institutes of Health, Public Health Service.

Read before the Thirty-second Annual Meeting of The American Association for Thoracic Surgery, Dallas, Texas, May 8-10, 1952.

*Cincinnati General Hospital, Christian R. Holmes Hospital, Good Samaritan Hospital, Jewish Hospital, Bethesda Hospital—all in Cincinnati; St. Elizabeth's Hospital, Covington, Kentucky; Veterans Administration Hospital, Dayton, Ohio; Our Lady of Mercy Hospital, Mariemont, Ohio.

In 4 instances the lesions were bronchial adenomas, in 1 there was a hamartoma, and in 2 the processes were diffuse lesions of unusual nature. These were excluded, leaving 87 specimens which were utilized as the basis for this report—all examples of indisputable bronchiogenic carcinoma.

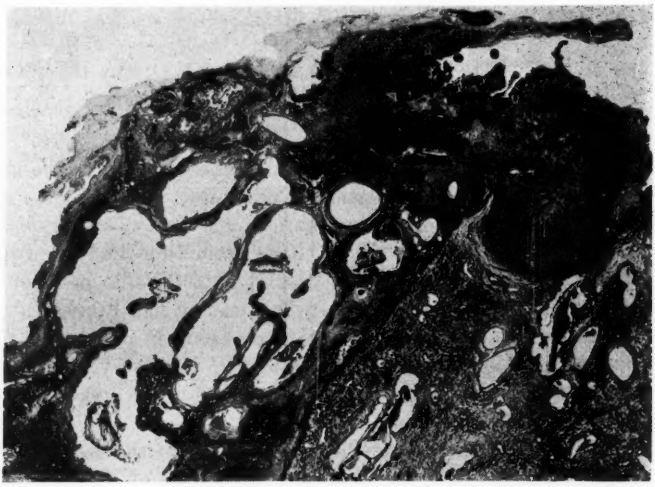


Fig. 1,*A*.—Bronchiogenic carcinoma occluding a bronchus in the right upper corner of the photograph. The upper lobe is atelectatic, the lower lobe the seat of severe bronchiectasis. The ink dots indicate the approximate extent (0.9 cm.) of a contiguous plaque of preinvasive carcinoma. (×1.2.)

Fig. 1,*B*.—High-power view of the contiguous plaque of preinvasive carcinoma in Fig. 1,*A*. Epithelial atypism and the intact basement membranes are noteworthy. (×300.)

Fifty of the specimens were obtained at autopsy and 37 by surgical excision. The lungs were delivered for processing as soon as possible after removal and an effort was made to procure roentgenograms of the inflated specimens. Formalin, 10 per cent, was introduced into the major bronchus at low pressure, and the entire specimen was immersed in vats of this fluid until fixation was completed. Full-length sections through the cancer-bearing lung were then prepared in

such a manner as to contain the bulk of the neoplasm, as much as possible of the bronchus to which it was related, and adjacent nonneoplastic pulmonary tissue. The area of the block was limited to 8 by 12 cm. by the size of the cover slips. If necessary, the tumor was divided in order that a full-length section of the pertinent bronchus could be retained in continuity with the tumor. The number of such blocks ranged from 1 to 4 per specimen; in the

Fig. 2,*A*.—A collapsed lobe with neoplastic bronchostenosis in a secondary bronchus indicated by the two ink dots. Extending proximally in the area outlined by the bracket is contiguous plaque of preinvasive carcinoma measuring 1.7 cm. (×1.2.)

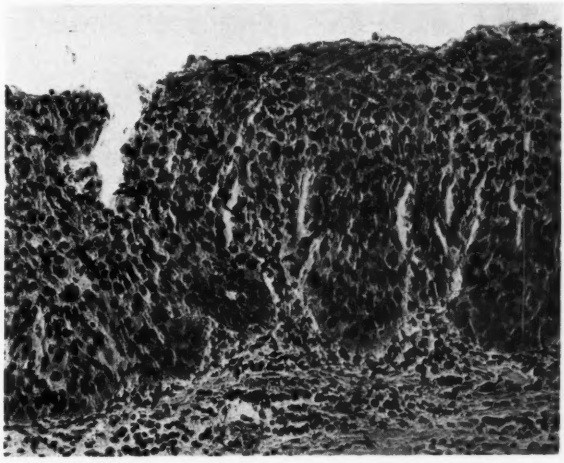


Fig. 2,*B*.—High-power view of the contiguous plaque in Fig. 2,*A*. The neoplastic appearance of the epithelium and the noninvasive character are apparent. (×300.)

great majority 2 large sections were prepared. In certain instances additional smaller samples were removed from areas which aroused interest and from these sections of conventional size were prepared.

The tissues were imbedded in paraffin and sections made on a large sliding microtome at thicknesses approximating 8 to 10 μ. Sections were uniformly stained with hematoxylin and eosin.

OBSERVATIONS

In the earlier study on the stomach[29] 3 microscopic features had proved to be of significant interest and the present investigation has been directed along similar lines. The features sought were (a) the presence of neoplastic alterations

Fig. 3,*A*.—Carcinoma straddling the bifurcation of a primary bronchus. The mucosa between the single ink mark and the bracket is nonneoplastic. The bracket outlines the position of an independent focus of carcinoma. (×1.2.)

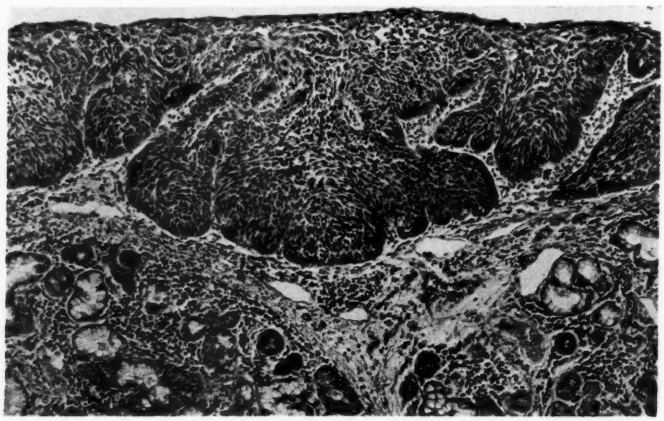


Fig. 3,*B*.—High-power view of the entire extent of the independent carcinoma in Fig. 3,*A*. Early invasion has occurred. (×90.)

of microscopic character in the mucosa immediately adjacent to the carcinoma, (b) the occurrence of independent foci of neoplasm of both gross and microscopic nature, and (c) the intratumor variations of histologic growth patterns.

In 13 specimens the bronchial mucosa in immediate continuity with the main tumor was found to be the seat of preinvasive squamous-cell carcinoma (Figs. 1 and 2). This lesion was characterized by metamorphosis of the normal bronchial epithelium into bizarre stratified squamous epithelium exhibiting nuclear atypism, mitotic figures in abundance, cellular pleomorphism, and loss

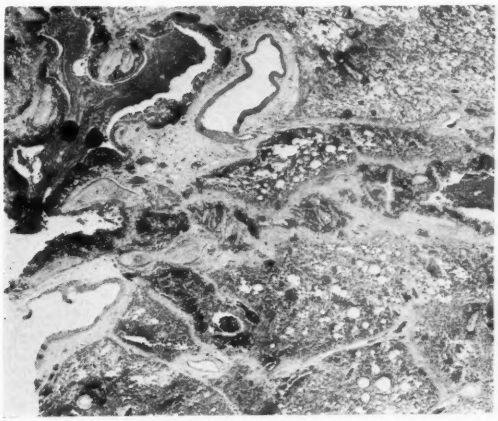


Fig. 4,*A*.—A partially collapsed lobe distal to an area of neoplastic bronchostenosis not shown in the photograph. In the upper left hand corner is the bifurcation of a bronchiectatic secondary bronchus filled with purulent exudate. The ink dots designate the location of three independent foci of neoplasm 3.5 and 5.0 cm. distal to the major tumor. (×1.2.)

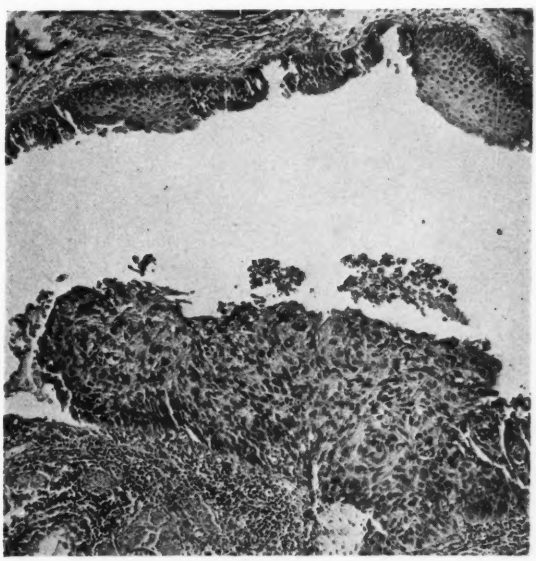
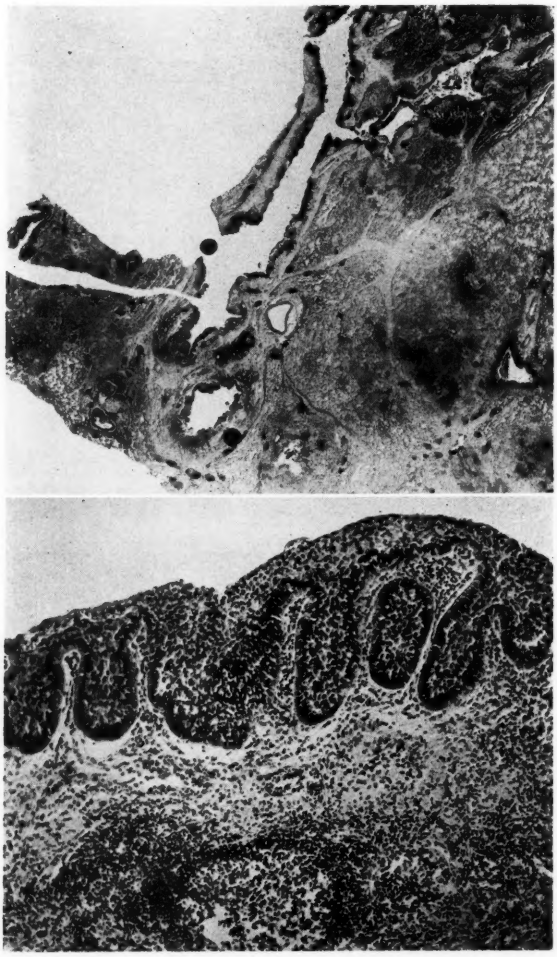


Fig. 4,*B*.—One of the foci indicated in Fig. 4,*A*. Note the contrast between the neoplastic focus below and the squamous metaplasia lining the remainder of the bronchus. (×90.)

of orientation. In general, the process was limited by an intact basement membrane (Figs. 1,*B* and 2,*B*). Occasionally the alteration appeared also within the ducts of bronchial glands similar to that seen in carcinoma in situ of the

A.



B.

Fig. 5,*A*.—A segment of lung the upper bronchus of which is the seat of carcinoma. The ink dots represent the location of two independent foci of neoplasm, 5.0 and 7.0 cm. proximal to the invasive cancer. (×1.2.)

Fig. 5,*B*.—One of the independent foci of preinvasive carcinoma shown in Fig. 5,*A*. (×90.)

cervix of the uterus. Rarely, the basement membrane was breeched by superficial invasion, thus attesting to the malignant potentiality of the lesion. Because of the shelflike character of the process and its intimate relation to the main

tumor, we have designated the alteration as the contiguous-plaque phenomenon. When more than one margin of a tumor was included in sections, contiguous plaques occasionally appeared in more than one site. They ranged in breadth from 1 or 2 mm. to as much as 7 cm. beyond the obvious limits of the tumor.

There were also found in 19 specimens identical microscopic foci which, however, lacked continuity with the main neoplasm. Believed to be independent growth centers, these small plaques of preinvasive carcinoma were separated by varying distances of unaltered mucosa (Figs. 3, 4, and 5). Indeed the intervening space ranged from 1 cm. to as much as 10 cm. and occasionally 2 to 6 such lesions were detected. Nor were they limited to the bronchus of major involvement, but appeared in subordinate branch bronchi both proximal and distal to the cancer and even in other lobes in which no neoplasm was suspected on gross inspection. Though usually of small extent (i.e., a single low-power field Figs. 3,*B* and 4,*B*), some of these lesions measured up to 3 cm. As was the case with the contiguous-plaque phenomenon, shallow invasion was observed on occasion.

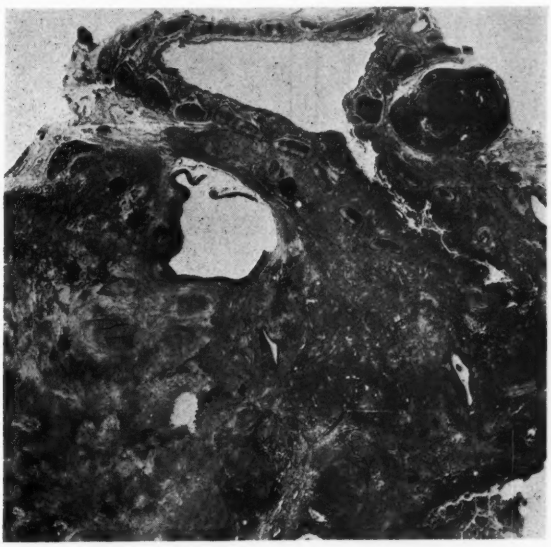
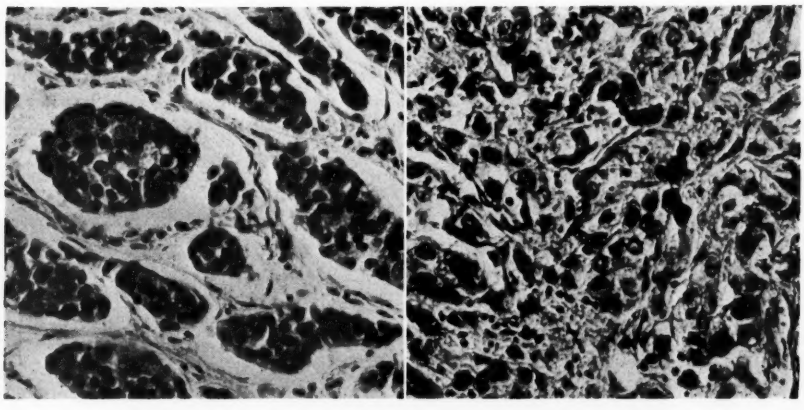


Fig. 6,*A*.—A bronchiogenic carcinoma obliterating the lumen of a bronchus in the right upper corner. The ink dots indicate the areas in which different histologic patterns are seen.

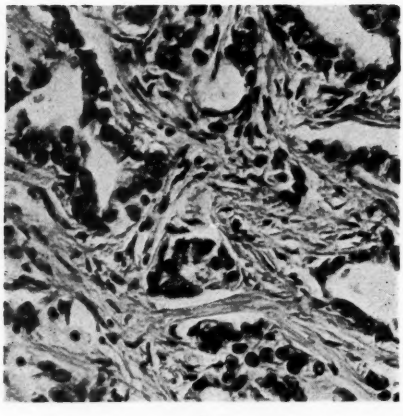
Both the contiguous plaque and the independent microscopic lesions appeared in the same lungs in 7 specimens. In 25 others either one or the other process alone was encountered. In 5 additional lungs 2 grossly visible independent carcinomas were observed.

The value of the large section technique was particularly demonstrated when the histologic structure of the neoplasms was scrutinized. Although pleomorphism has been remarked repeatedly in bronchiogenic carcinomas,[30] the

degree actually observed in this series was most impressive. Less than half of the neoplasms (42 specimens) revealed only a single type of architecture throughout. In the remaining 45 cases, as shown in Table I, 116 different structural patterns were encountered. In many, of course, the variation might



B. *C.*



D.

Fig. 6,*B*.—High-power view in region of an ink dot in Fig. 6,*A*. The pattern here is that of a small cluster alveolar carcinoma. (All high-power views in Figs. 6 and 7 are taken at identical magnification.)

Fig. 6,*C*.—Another focus in Fig 6,*A* showing an undifferentiated nonorganoid pattern.

Fig. 6,*D*.—A third structural pattern in the tumor shown in Fig. 6,*A*. Here the lesion is a well-differentiated adenocarcinoma.

be considered to be one of degrees of differentiation of a single type of cell. But in a goodly number no possible developmental relationship could be attributed to the 2 or more patterns noted in a single tumor mass (Figs. 6 and 7). In this category were combinations of well-differentiated squamous-cell car-

cinoma with equally well-differentiated adenocarcinoma, spindle-cell alveolar carcinoma in association with oat-cell carcinoma, anaplastic giant-cell carcinoma, or even formless clusters of signet-ring carcinoma.

There were 2 patterns evident in 27 tumors, 3 in 16 cases, and 4 or 5 patterns in 6 instances. Despite the marked intermixture of patterns frequently encountered, the use of the dissecting microscope revealed a geographic distribution of such nature as to indicate that this occurred only at points of juxtaposition. As one moved away from these zones one or another variant became predominant and relatively discrete. Often one or more patterns recurred in different portions of a tumor producing a mosaic structure. Usually, however, each type occupied its own segment and was not recurrent within the tumor mass itself, although it was often reproduced in one or more metastatic sites.

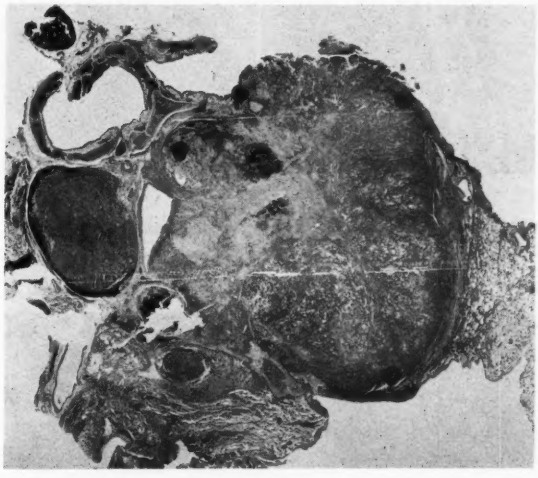


Fig. 7,A.—Bronchiogenic carcinoma entering the lumen of a major bronchus in the upper margin of the photograph. Ink dots represent the areas of varied histology observed in this lesion.

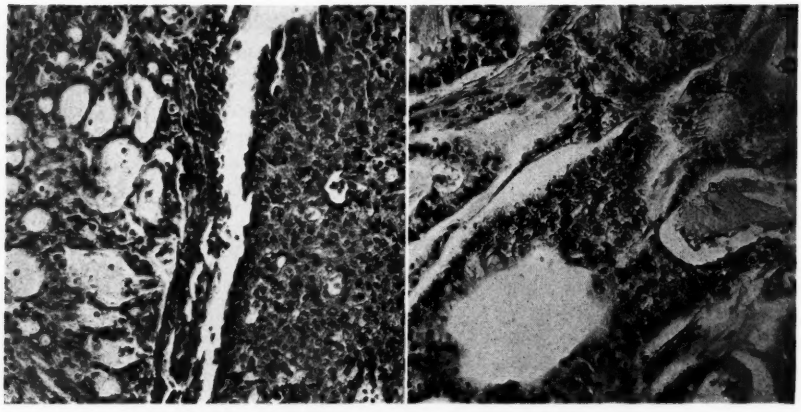
DISCUSSION

Intraneoplastic pleomorphism is commonly considered evidence of tumor cell multipotentiality. This need not, however, invariably be the case. If one visualizes the panoramic distribution of patterns in a given tumor by means of the dissecting microscope, multipotentiality does not always appear to be a logical explanation for the existing arrangement. Under these circumstances, it would seem more reasonable to attribute the phenomenon to coalescence of

TABLE I. PULMONARY CARCINOMA, STRUCTURAL PATTERN

1 type	42 cases
2 types	27 cases
3 types	12 cases
4 types	4 cases
5 types	2 cases

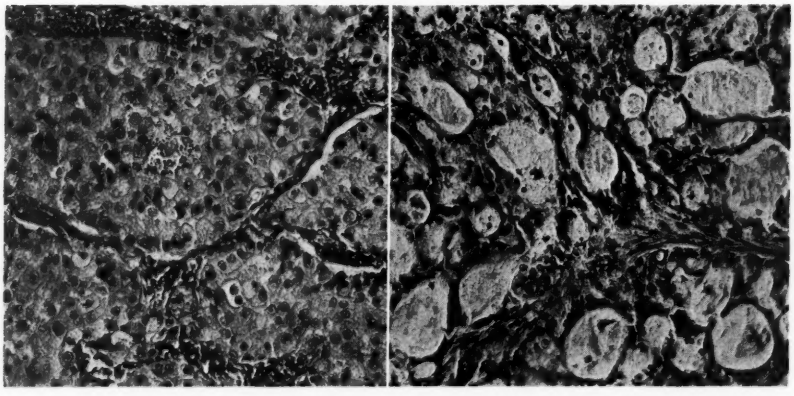
2 or more neighboring neoplasms, each of which arose independently and with different polarization. Thus there would result intermixture of structural types at points of impingement but retention of the original architecture throughout the remainder of the lesion.



B. *C.*

Fig. 7,*B*.—A juncture zone in Fig. 7,*A* demonstrating adenocarcinoma on the left and squamous-cell carcinoma on the right.

Fig. 7,*C*.—A region in Fig. 7,*A* showing large acinus mucus-secreting adenocarcinoma.



D. *E.*

Fig. 7,*D*.—Another zone comprised of alveolar squamous-cell carcinoma.

Fig. 7,*E*.—In this area the tumor has the structure of a small acinus adenocarcinoma. The secretion here is nonmucinous.

Coupling the complexity of histologic patterns with the frequent occurrence of independent and contiguous neoplasms of both gross and microscopic size (Table II), it would seem reasonable to presume that many bronchiogenic carcinomas arise not from one, but from several proximate sites. In only 33 of

the 87 cases were none of the features considered contributory to this hypothesis detected. The evidence becomes even more convincing when one appreciates the fact that in many cases in which the pertinent lesions were observed, they appeared in only one of several sections, while in other tumors in which none were found only single blocks had been sectioned. In the gastric carcinoma study when additional blocks were made in stomachs which had failed to exhibit the lesions searched for, they often became manifest in sections prepared in other areas. Thus there is reason to believe that serial sectioning of the lungs also would probably increase the incidence rate.

There exists doubt in some quarters that the process termed preinvasive carcinoma is an irreversible one and inevitably proceeds to the invasive state. Frank, albeit early, invasion was observed to stem from several in situ plaques in this series (Figs. 3,*B*). This by no means settles the problem of inevitability of invasion, but certainly substantiates the concept of malignant potentiality.

TABLE II. PULMONARY CARCINOMA; EVIDENCE FOR MULTIPLE SITES OF ORIGIN

None		35 cases
Multiple gross neoplasms	5	52 cases
Independent foci microscopic neoplasm	19	
Contiguous plaque phenomenon	13	
Varied histologic pattern	46	

In this respect it is important that we clarify the distinction between preinvasive carcinoma and squamous metaplasia of bronchial mucosa. In the examples we have accepted we believe the distinction to be unequivocal (Fig. 4,*B*). Squamous metaplasia was an exceedingly common occurrence in these specimens and though occasionally exhibiting isolated cell or nuclear atypism, such areas always appeared to retain both polarity and orientation and rarely revealed significant mitotic activity. So far as the data here presented are concerned, when any question existed in this respect, the lesion was not classified as neoplastic.

Perhaps the matter of distinction between independent neoplasms and metastasis requires further clarification. Among the small group of grossly recognizable lesions, this distinction could not be made with certainty, although the relation to bronchial passages, and the cytologic variation led us to believe that they were indeed independent tumors. The preinvasive plaques, on the other hand, were so characteristic, were wholly unrelated to lymphatic extensions, and showed so little similarity of architecture to the grossly presenting tumor that there seemed little room for doubt of their independence of origin.

SUMMARY

Large tissue sections were prepared from 87 lungs containing bronchiogenic carcinoma.

In 5 of these there were 2 grossly visible primary carcinomas in the same or different lobes.

In 25 other specimens there were found, on microscopic examination, plaques of preinvasive or early invasive carcinoma both in close contiguity with the main tumor or at such a distance from it as to be considered independent lesions.

In 53 per cent of the cases the major presenting tumor contained 2 to 5 different histologic patterns arranged in such manner as to imply initial independence and ultimate fusion of neighboring neoplasms.

The majority (63 per cent) of the specimens examined exhibited one or more of the features enumerated above.

It is believed that the aggregate of these observations lends weight to the hypothesis that bronchiogenic carcinoma may often arise from more than one site and that frequently clinical recognition does not occur until coalescence of independent growths has been completed.

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DISCUSSION

DR. J. R. MC DONALD, Rochester, Minn.—I wish to congratulate Dr. McGrath on the interesting observations he has reported. I wish to reiterate some of the observations we have made in connection with proximal extension in squamous-cell carcinoma of the bronchus. We have noted for some time that between 15 and 20 per cent of squamous-cell carcinomas of the bronchus show this noninvasive phenomenon proximally. This is of great importance to the thoracic surgeon because the noninvasive part of the lesion cannot be recognized grossly. Therefore, if the surgeon cuts across it there will be a recurrence in the stump, and I think that accounts for a great many stump recurrences in resections of bronchiogenic carcinoma of the squamous type.

The other thing is that one case has been reported in the literature by Papanicolaou in which the entire squamous lesion in the bronchus was in situ. I think this is important because in this particular case there was a positive cytologic examination, and many physicians and surgeons would have accused the cytologists of issuing a false positive report. As it was, the case was resected and unquestionably the patient was cured.

DR. H. BRODIE STEPHENS, San Francisco.—I should like to ask Dr. McDonald how one can tell from cytology alone on which side the carcinoma is? That refers to the case recently reported by Dr. Papanicolaou.

DR. J. R. MC DONALD, Rochester, Minn.—That is a very difficult problem. Differential cytology on bronchial secretions would help, but in differential cytology, of course, there may be a spillover from one bronchus to another. The only positive way would be to obtain a biopsy, with the chance of obtaining a biopsy by bronchoscopy. But I do not think one should blame cytologists for every false positive that occurs.

DR. MC GRATH (Closing).—There may be some answer to Dr. Stephens' question. In Dr. Papanicolaou's case there had been repeated bronchoscopies on that particular patient and repeatedly positive cytologic findings from the same side. I would like to utilize some of the remaining time to show tables summarizing our findings.

(Slide.) These are the several patterns which we found, and (Slide) this shows the summaries of the entire study made.

I am grateful that Dr. McDonald drew the obvious inferences from this study. One is, emphasis upon the necessity for a high amputation of the bronchial stump. Furthermore, it is our feeling that we are not in the least enthusiastic, except under extremely extenuating circumstances, about lobectomy in the treatment of bronchiogenic carcinoma.

THE USE OF SK-SD(VARIDASE) IN THE MANAGEMENT OF EARLY POSTOPERATIVE PARTIAL PULMONARY RESECTIONS

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THE applicability of SK-SD(Varidase) as a therapeutic measure against fibrinous, purulent, and sanguineous collections has been well demonstrated.[1-3] Used within the thorax the enzymes have been shown to be practical and of considerable value in a variety of situations arising in medical and surgical thoracic patients, and previous reports describe in detail their use in hemothorax, postpneumonic, and chronic empyemata.[4-7] In those reports either total resection of a lung had been accomplished or the presence of lung collapsed by a coagulum presented the problems under consideration among the cases cited.

Instances of partial pulmonary resection were not encountered among the reported patients undergoing treatment with the enzymes. However, their use in one case of lobectomy was accomplished by the author in 1949 with a successful result, but a report of two failures after similar procedures with evidence of fistulae occurred subsequent to that.[8]

Since the enzymes uniquely lyse fibrinous deposits and nucleoprotein, which essentially form the framework of the bronchial stump-healing processes,[9] some hesitation has existed in the application of SK-SD to early postoperative partial pulmonary resection cases. It has been pointed out previously that a fistula may be dormant or occult and prevented from becoming manifest by the tamponing effect of fibrin or debris but, with dissolution of the latter, leakage occurs.[10] For these reasons when the enzymes are used after partial pulmonary resections, it is mandatory that drainage tubes are in situ and suction is available so that the immediate, or delayed, escape of air and fluid follows. Prompt re-expansion of the remaining lung tissue can thus be brought about. There is no evidence that the enzymes create fistulae but only that they become apparent when they already exist; the enzymes have no effect on living cells.[11]

Creech, De Bakey, and Amspacher, in experimental studies, have shown that the use of SK-SD during the early postoperative period following pneumonectomy did not interfere with the healing process of either the bronchial stump or the ligated vessels when the procedure was properly performed.[12] These same authors emphasized the necessity of meticulous pleuralization of the bronchial stump as a guard against fistulae when SK-SD was used. If proper pleuralization were not accomplished, they inferred that bronchial stump healing then depended upon the integrity of the clot formed about the stump. If this clot were dissolved by the fibrin-lysing system, the framework for early healing would be removed and, unless an intact bronchial stump were present,

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a fistula might become manifest. These technical points were considered essential previously when SK-SD was used in patients following pulmonary resection surgery.[10]

Many surgeons no doubt have had the experience of observing good drainage from thoracotomy tubes early postoperatively but not infrequently, for some inexplicable reason after a period of 24 to 48 hours' drainage, becomes sluggish and finally ceases when clotting occurs within the tube. Roentgenograms of the chest then reveal evidences of an accumulation within the operated hemithorax and physical findings reflect the evidence of a space-filling coagulum. In these situations no amount of maneuvering or manipulation with the drainage tubes is of avail. One then may attempt aspiration and get nothing or, at the most, a few cubic centimeters of serous fluid. The operator must then be satisfied with incomplete drainage of the thorax and trust that the residual coagulum will be absorbed, and the density seen by roentgenogram will fade spontaneously. If the situation is worse thoughts may be turned to decortication after a reasonable period of time has passed and further possible clearing appears remote. In either event a well-performed technical procedure is marred by a frustrating complication. Large accumulations within the chest often defy prompt attempts at treatment and therefore demand more attention than small collections which frequently vanish even without aspiration.

With the previous experience gained in the use of the enzymes in various types of hemothorax and with the clinical observation in one case of partial pulmonary resection, elaboration upon the application of the enzymes in similar situations, where their use might be indicated, appeared justified. It was reasoned that by controlling leakage of air and fluid with drainage bottles and suction after the instillation of the enzymes the behavior of the remaining lung tissues would resemble that immediately following operation. Under these conditions re-expansion could take place without the presence of excessive amounts of fluid imbued with coagulating tendencies.

Six cases of partial pulmonary resection, in which evidences of coagula existed, treated early postoperatively with the streptococcal enzymes, constitute the substance of this report. The cases included are as follows.

1. Right upper lobectomy and resection of the superior segment of the right lower lobes.

2. Basilar segmental resection left lower lobe.

3. Right upper lobectomy and enucleation of caseous tuberculous foci from the superior segment of the right lower lobe, and decortication of the right lower and middle lobes.

4. Apical and posterior segmental resection right upper lobe with decortication right middle and lower lobes.

5. Apical and posterior segmental resection right upper lobe with enucleation of foci from the anterior segment of the right upper lobe and superior segment of the right lower lobe.

6. Enucleation of a coccidioidomycotic cavity from the left upper and contiguous left lower lobes.

It is to be noted that in addition to partial resection of lung tissue several combined procedures were performed such as enucleation of tuberculous foci and decortication of the remaining lung tissue.

With so few cases, no claim is made for dramatic results having been obtained in the form of complete clearing by roentgenogram and physical findings. However, the progress of the patient was enhanced in most instances and neither ill effects relative to fistulae were incurred nor was wound healing jeopardized.

The diseases encountered at operation, and diagnosed histopathologically, were tuberculosis, three cases; coccidioidal granuloma, two cases; and bronchiectasis, one case. Cultures for pyogenic organisms and acid-fast bacilli were reported negative when fluids were submitted for examination. In no cases was there, at the time of treatment, either laboratory or clinical evidence of an infected hemothorax or empyema.

MATERIALS AND METHODS

The streptococcal enzymes (now known as Varidase) used in this study were prepared by methods described by Christensen[13] and modified by Lederle Laboratories, Inc.* to meet commercial production requirements.

Coagula forming within the postoperative chest are composed of blood clot, fibrinous gel accumulations, and a combination of products of exudation. If infection takes place empyema may be the end result. In the situations under discussion no evidence of infection was present and the substrate requiring dissolution was sanguineous or fibrinous in quality. The streptokinase component in the dual enzyme system was therefore the important factor in management of the problems under consideration. The presence of the streptodornase increment does not detract from the action of streptokinase. As noted previously laboratory control measurements are not necessary for the practical and effective clinical application of streptokinase except in infrequent instances.[4]

Dosage.—Details relative to mixing the lyophilized materials and data concerning the dosages employed are outlined in a previous article.[4] For the present group of cases at least 100,000 units per injection of SK-SD were employed. When the larger drainage tube was selected the enzymes were dissolved in at least 30 c.c. of saline and if the smaller drainage tube was chosen 20 c.c. of diluent was used. In only one case was the treatment with the enzymes repeated.

SUMMARY OF DATA RELATIVE TO THE TREATMENT OF PATIENTS

Operative Technique.—The anesthesia was conducted with an endotracheal tube in place and usually consisted of nitrous oxide, oxygen, and pentothal with syncurine induction. All the operations were performed through the usual posterolateral approach with silk technique. The rib msot advantageously situated near the diseased area was removed subperiosteally. For upper lobe

*Lederle Laboratories, Inc., Pearl River, N. Y., supplied the material used in this study.

disease, frequently the fourth rib was removed. Individual ligation technique was used on hilar and subhilar structures. The bronchial stump was meticulously and thoroughly pleuralized. In segmental resections no attempt was made to pleuralize the raw surfaces. Before closure a No. 22 French catheter with two holes was introduced through the second anterior interspace and fixed to the cupola of the hemithorax. A large fenestrated latex rubber tube was introduced through a subjacent rib space and this was connected to a water seal during closure. Both tubes were connected to water seals and suction was added during the early postoperative course. Controlled suction was available at the time of treatment with the enzymes. All the patients received penicillin pre- and postoperatively and those with a diagnosis of tuberculosis in addition received streptomycin. One patient also received terramycin.

When a patient was selected for treatment one of the drainage tubes, usually the lower one, was clamped off approximately 2 inches from the chest wall. The length of tube proximal to the clamp was then painted with Merthiolate or with another suitable antiseptic agent. The dissolved enzymes were drawn into a syringe with additional saline and forcibly injected into the chest through an attached 18-gauge needle inserted into the tube through the prepared area. If the smaller upper or anterior tube was used the mixture was instilled simply by attaching the syringe to the lumen of the tube.

Although streptokinase, when instilled, immediately activates the lysing system responsible for the dissolution of fibrin loculations and lysis of coagula within the thorax, the completion of the process occurs at variable periods of time. This time factor is essentially determined by the physical form of the coagulum and the extent of contact between enzymes and substrate.[3, 4] However, a considerable portion of the expected lysis may occur within three to six hours, and this treatment time was arbitrarily chosen for the cases observed in this article.

Careful observations were made of the patients treated and, if the clinical picture necessitated termination of the treatment, the treatment time was reduced accordingly. However, this occurred on only one occasion but in another instance at the end of six hours one patient had some respiratory difficulty which was relieved by the opening of his drainage tubes with the accompanying escape of air and fluid. Observations were made for the escape of air when one tube was clamped off; the other remained open and measurements were made of the fluid presumably produced as the result of the action of the enzyme system. In addition to frequent physical examinations, chest roentgenograms were made as soon after treatment as possible and subsequently as indicated.

Untoward manifestations directly due to the use of the enzymes for the most part consisted of rather prompt rise in the temperature, usually about 2° F. The febrile response lasted only about twenty-four hours by which time the fever had reached a peak and dropped precipitously to the original pretreatment level or lower. Minor toxic manifestations consisted of loss of appetite, malaise and a few patients complained of increased pain.

CLINICAL RESULTS AND CASE REPORTS

PATIENT MRS. G. R.—This 43-year-old white woman had known tuberculosis since April, 1949. A roentgenogram then revealed cavitary disease in the right upper lobe. Following the discovery of her disease she was hospitalized from May to July, 1949, and a right pneumothorax was attempted. She received 1 Gm. streptomycin twice a week and Paraminosalicylic acid during this hospitalization. She was discharged on modified bedrest. She continued her modified bedrest at home for a year and one-half when she again began to increase her privileges although the roentgenogram at that time did not show complete healing of the disease in the right upper lung field. In June, 1951, her sputum was re-examined and found to be positive for AFB. A roentgenogram of the chest revealed heterogeneous densities in the right upper lobe region with areas of radiolucency. Her past history was noncontributory except that in January of 1950 she was found to have mild diabetes and required very small doses of insulin on occasions but usually the diabetes was controlled by diet alone.

Physical examination and review of the roentgenograms disclosed evidence of chronic tuberculosis fairly well confined to the right upper lobe region.

Operation July 12, 1951.—The apical and posterior segments of the right upper lobe were found to be markedly shrunken, nodular and firm. There was a complete pleural fibrous symphysis over this region and extrapleural dissection was necessary. The anterior segment of the right upper lobe was reduced in size and in addition presented two large nodular areas within its substance. Focal areas of disease were palpable in the superior segment of the right lower lobe. A right upper lobe lobectomy and a superior segmental resection of the right lower lobe was performed. A catheter was introduced anteriorly and fixed in the cupola of the hemithorax and a large fenestrated latex rubber tube was introduced posteriorly for drainage purposes.

Histopathological diagnosis: Tuberculosis.

Postoperative Course.—The patient's temperature rose to 104° F. (rectally) by the second postoperative day but thereafter fell by lysis and was low grade by the fifth postoperative day. Both water seal bottles connected to 15 cm. of water suction drained fluid and air in moderately large quantities through the second postoperative day. On the third postoperative day there was very little drainage and no further air leaks were noted. By the fifth postoperative day the lower tube had stopped functioning although the upper tube continued to drain small amounts of fluid. The lower drainage tube was removed that day but the roentgenogram taken at that time disclosed evidences of either fluid or a coagulum in the lower lung field. The breath sounds had gradually become more diminished. On the eighth day additional roentgenograms of the chest showed increased amount of fluid in the operated chest and on attempted aspiration only 10 c.c. of bloody fluid could be aspirated from two posterior sites (Fig. 1).

The anterior tube had stopped draining. Ampules of SK-SD(Varidase) were injected simultaneously into the anterior tube and into the chest where small amounts of bloody fluid could be obtained. The upper drainage tube was allowed to remain open. On July 21, twenty-four hours after the injection of the Varidase, 500 c.c. of fluid had drained into the bottle and, in addition, 75 c.c. of fluid was aspirated from a selected posterior site. The following day, July 23 (three days after SK-SD), roentgenograms and fluoroscopy revealed very marked clearing of the hemithorax (Fig. 2).

The upper tube was then removed and the patient was discharged three days later, on July 25, for further convalescence.

The patient was seen intermittently one month, three months, and eight months following operation. By fluoroscopy and roentgen examination, the operated chest continued to show clearing and her postoperative course was considered entirely satisfactory (Fig. 3).

A subsequent report from her physician indicates that the patient has negative sputum and continues to be recovering satisfactorily.

Comment.—This patient had resection surgery for tuberculosis and postoperatively presented evidences of incomplete drainage of the operated hemithorax with roentgen evidences

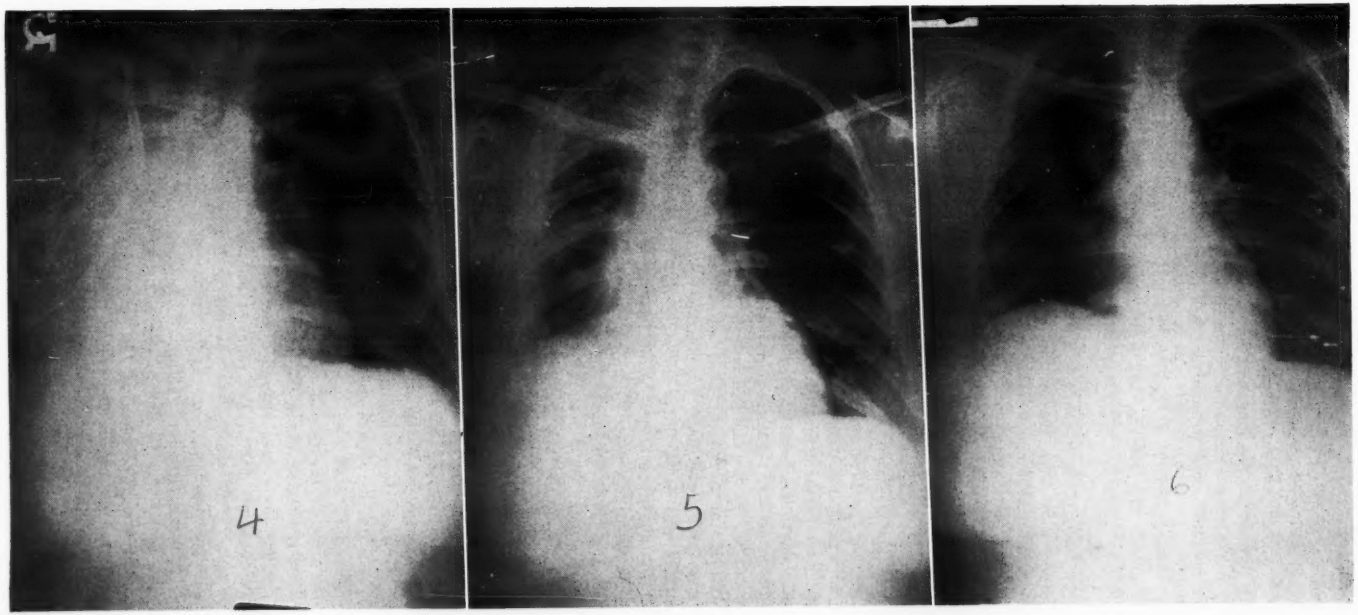

Fig. 1. Fig. 2. Fig. 3.

Fig. 1 (Patient Mrs. G. R.).—Roentgenogram appearance of the right hemithorax on July 20, the eighth postoperative day, immediately before the instillation of the enzymes into the chest (the lower or posterior tube had been removed previously).

Fig. 2 (Patient Mrs. G. R.).—Roentgenogram of the chest taken July 23, three days after treatment with the enzymes. There has been dramatic clearing and there was comparable improvement in the physical findings over the operated side.

Fig. 3 (Patient Mrs. G. R.).—Posteroanterior roentgenogram of the chest about five months following operation showing further clearing of the posttreatment pleural reaction.

of increased opacity of the operated side and diminished to absent breath sounds on physical examination. Following the introduction of Varidase there was a prompt drainage of the liquefied coagulum with a small amount of leakage of air which permitted complete re-expansion of the remaining portion of the lung and no evidence of chronic fistula was ever encountered. Follow-up has been continued for approximately eight months and there is continued clearing of the operated chest without evidence of recrudescence of the disease.

PATIENT O. J.—This 27-year-old white man had left lower lobe pneumonia at the age of five years. He had cough and sputum as long as he could remember and his sputum was frequently purulent and varied in amounts. Intermittent mild hemoptyses occurred for almost ten years.

Essential physical findings were confined to the chest where numerous rhonchi and medium moist râles were heard over the left lower lobe posteriorly. The bronchographic examination disclosed cylindrical bronchiectasis in a shrunken basilar division of the left lower lobe. The remaining portions of both lungs were within normal limits.

Initially the patient brought up over an ounce of purulent sputum daily but with antimicrobial therapy and aerosol penicillin this was reduced to scant amounts of mucoid sputum.

Operation, November 5, 1951.—A segmental resection of the basilar segments of the left lower lobe was performed. The chest was drained only with a large posterior tube in this instance and no anterior tube was used.

Postoperative Course.—The tube bubbled for about forty-eight hours and drained about 500 c.c. of bloody fluid. Tracheal suction was performed frequently following operation. His temperature rose immediately after operation and reached a maximum of about 103.6° F. on the fourth postoperative day. His breathing on the third day was somewhat difficult despite tracheal suction and bronchoscopy. Roentgenographs of the chest showed a marked opacity in the left hemithorax and SK-SD was instilled into the posterior tube. Subsequently there was slight clearing with drainage of 200 c.c. of fluid but two loculated areas appeared anteriorly and superiorly over the left upper lobe. Aspiration was of no benefit. The tube was removed on the fifth postoperative day. By the sixth day it was quite evident that a large coagulum existed over the left upper lobe. Additional taps failed to yield any fluid. The temperature was 103° F. from November 11 to November 14.

On November 15, the chest was reopened and decortication was performed. Upper and lower tubes were inserted. On November 16, the day after decortication, additional SK-SD was instilled into the upper tube and there was a prompt drainage of about 300 c.c. of fluid in the lower bottle. On November 19, the tubes were out, but there was some increased density over the lower lung field. The temperature again rose to 103° F. and there were a few râles in the upper chest. However on increased medication including terramycin and streptomycin the temperature fell by lysis and was normal during the subsequent forty-eight hours. The sutures were removed on November 21 and roentgenograms on November 23 showed very much improvement. All the cultures obtained from the chest were negative. The sputum disclosed an organism resembling aerobacter aerogenes. The patient was discharged November 24 for further convalescence and has shown marked clearing in the operated side. He returned to work and has had no further complaints.

Comment.—At the time of the second thoracotomy it was noted that the only clean pleural surfaces existed in the region where the posterior tube had functioned. The enlarged superior segment of the left lower lobe showed a small area of induration adjacent to the diaphragm to which it was firmly fixed. The segment was well aerated and could be easily reinflated whereas the upper lobe which was covered with the recently formed peel and fibrinous exudate was difficult to reinflate. It is to be noted that although SK-SD was instilled into the lower tube complete liquefaction of the coagulum in the entire hemithorax did not occur. This was thought to be due to the fact that early organization had begun and limited the area of treatment, preventing the enzymes from permeating the collection, anteriorly and superiorly over the upper lobe region. Because at the time of aspiration no definite evidence could be obtained that the needle was in an area of fluid or coagulum enzymes were not instilled into this region. In previous reports a word of caution was rendered to make sure that the needle was in the proper position and some fluid could be

aspirated before the enzymes were instilled. Observing such precautions prevents the injection of the enzymatic solution into the lung parenchyma. In this case if an anterior tube had been used perhaps the foregoing complication could have been circumvented.

An additional point to be gained in this situation, although not classified as an example of successful treatment with the enzymes, is that on the day following decortication enzymes were instilled into the operated area in an effort to hasten the liquefaction of any residual or newly formed coagulum. Despite the short interval (one day) between operation and the use of the enzymes there was no evidence of leakage through the thoracotomy site and the healing of the wound occurred unaltered. The patient was examined approximately five months after operation and has shown almost complete clearing of the operated chest.

PATIENT MRS. H. G.—This 27-year-old white woman was first examined on July 17, 1951. In March, 1951, the patient was seen by her physician for what was diagnosed as a "strep throat." She had a moderately productive cough and some evidences of sinusitis. She had lost some weight and had malaise. Sputum obtained by the physician was positive for acid-fast bacilli. A roentgen examination of the chest disclosed evidences of fibroulcerative tuberculosis of the right upper lobe and a large nodule subjacent to this region thought to be in the superior segment of the lower lobe. In January, 1948, when this patient was hospitalized for childbirth roentgenogram of the chest disclosed a similar large density in the right upper lobe region. At that time she had no symptoms and the roentgenographs were interpreted as showing chronic pneumonia.

Positive physical findings were confined to the chest where dullness to percussion over the right upper lobe was apparent. Breath sounds were harsh in this region but no râles were audible. The left side was entirely negative.

Operation, August 4, 1951.—Upon entering the right hemithorax a complete pleural symphysis was found. The right upper lobe was found to be shrunken, airless, nodular, and firm. A thin fibrous envelope surrounded the lower and middle lobes when they were freed. The right upper lobe was removed by extra-and intrapleural dissection. The major and minor fissures were incomplete and sharp dissection was necessary to remove the upper lobe from the contiguous portion of the adjacent middle and lower lobes. One large firm nodule was palpable in the superior segment of the right lower lobe and this was enucleated. A second smaller nodule inferior to the larger one was likewise enucleated. The areas in which the enucleation was accomplished were approximated with mattress sutures of fine silk. The fibrous peel over the remaining portion of the lung was removed by blunt and sharp dissection. This permitted good re-expansion of the middle and lower lobes on re-inflation. It was noted then that there was poor aeration of the firm superior segment of the lower lobe. The chest was closed in the usual manner and posterior and anterior tubes were inserted for drainage purposes.

Postoperative Course.—During the first postoperative day the breath sounds over the operated side were satisfactory. The usual amount of drainage into the water seal system and bubbling indicating air leakage continued for the first twenty-four hours. Late the first postoperative day a leakage in the large drainage tube was discovered where it was attached to the glass tube. This leak was repaired but on examination of the chest the breath sounds were found to be diminished and poor drainage from the hemithorax was suspected. On the second postoperative day, August 6, roentgen examination showed an opacity over the entire operated side (Fig. 4).

Because of the preceding events and the possibility of coagulum having collected within the operated chest, ampules of Varidase were instilled into the upper and lower tubes. It was the plan at that time to leave them clamped for a period of from four to six hours. However at the end of three hours the patient complained of some shortness of breath with increased chest pain. It was thought that her complaints were more apparent than real but nevertheless the symptoms were accepted as bona fide and three hours after the Varidase had been instilled the tubes were opened. There was an immediate escape of about 100 c.c. of fluid and a few bubbles of air into each drainage bottle. On August 7, the third postoperative day, another 100 c.c. had drained into the upper tube drainage bottle and another 150 c.c. had accumulated in the lower drainage tube bottle. The upper tube at

that time was removed. On the fourth postoperative day, there had been approximately 50 to 75 c.c. more drainage into the lower tube drainage bottle and physical findings indicated that the breath sounds were improved and roentgen examination revealed some clearing. The lower tube was removed later that day. After the instillation of the Varidase the temperature promptly rose to 102.8° F. but in twenty-four hours it had subsided to 100° F. and thereafter it continued as low grade to normal. On the sixth postoperative day the breath sounds were good but some haziness on the roentgenograms still existed (Fig. 5). An aspiration in the posterior axillary line on the day failed to yield any fluid.

Because of the existing density in the upper portion of the hemithorax, its failure to clear with the treatment outlined and due to the fact that an upper lobe lobectomy had been accomplished, a modified thoracoplasty was performed on the seventeenth postoperative day, August 21. This operation consisted of removal of the entire first rib and segments of ribs two and three. The transverse processes and posterior rib stumps were left intact. The patient made an uneventful recovery from the thoracoplasty and was discharged on August 28, one week following the thoracoplasty and twenty-four days following the lobectomy.

The pathologic specimen showed fibrocaseous tuberculosis and the nodules submitted for examination showed caseous centers.

At follow-up one month and three months after surgery she had made an apparently uneventful recovery. Sputum by culture was negative for acid-fast bacilli. Roentgenograms continued to show clearing in the operated chest (Fig. 6). The last follow-up on this patient was in March, 1952, almost eight months after operation, at which time there was evidence of continued improvement.

Comment.—In this particular situation it was thought that due to the leakage of the drainage system a coagulum had been permitted to form and Varidase was used to liquefy this coagulum and permit further drainage. The persistent haziness over the lung was thought in part to be due to the pleural reaction since this patient had decortication of the envelope of fibrous tissue described at operation. No evidence of fistula became manifest and satisfactory re-expansion occurred and progressive clearing by x-ray examination was evident.

PATIENT MRS. O. C.—This 34-year-old white woman had known tuberculosis since 1941. Following a brisk hemoptysis her sputum was found to be positive. A roentgenogram showed a cavitary lesion in the right upper lobe area. She was hospitalized in December, 1941, and a right pneumothorax was instituted. She remained in a sanatorium for approximately one year and the pneumothorax on the right was maintained. About a year and one-half later she was told that her disease was healed and the sputum was negative. Following a pregnancy and a hysterectomy in November, 1943, her sputum was again found to be positive. Hemoptysis recurred in January, 1944, and she re-entered a sanatorium. A right phrenic crush was performed in 1945. After continued bedrest, the sputums were said to be negative for acid-fast bacilli on culture and the disease was thought to be arrested. She gained about twenty pounds and was working as a student x-ray technician when she was re-examined in June, 1951, following some streaking, and the sputum was again found to be positive. At the time of the examination in June, 1951, she had minimal symptoms and scant cough and sputum.

Physical examination yielded contributory findings only in the thorax. On auscultation over the posterior right upper lobe region the breath sounds were of increased intensity. No adventitious breath sounds were heard. The left side was completely negative. At fluoroscopic examination the right diaphragm was seen to move sluggishly. On roentgen examination, heterogeneous densities were present in the right upper lobe region posteriorly. Tomography disclosed evidences of a cavity in the apex of the right upper lobe.

Operation, July 20, 1951.—On opening the right hemithorax a total and complete fibrous pleural symphysis was found to exist. When the lung was freed it was noted that a fairly thick fibrous envelope enclosed it. The pleural peel was subsequently stripped from the remaining portions of the lung following the resection of the apical and posterior segments. A few small nodules were found in the extreme posterior part of the anterior segment and

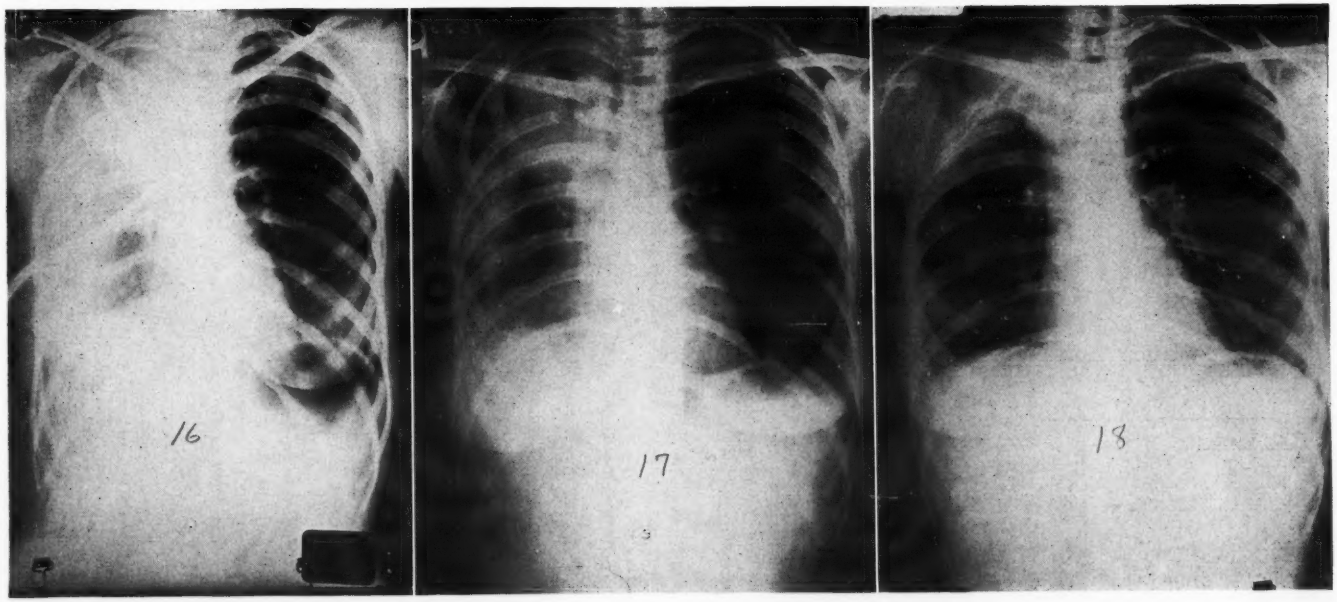

Fig. 4. Fig. 5. Fig. 6.

Fig. 4 (Patient Mrs. H. G.).—Depicts the roentgenogram appearance (first postoperative day) before treatment with SK-SD(Varidase). A large collection obscures the entire right hemithorax except a small portion of lung at the base.

Fig. 5 (Patient Mrs. H. G.).—The roentgenogram taken on the tenth postoperative day about one week after treatment. There has been moderately good clearing of the density seen previously but the superior portion remains obscured.

Fig. 6 (Patient Mrs. H. G.).—A follow-up roentgenogram of the chest made approximately five months after operation. A thoracoplasty has been done and excellent clearing of the remaining lung is evident.

these were removed with the resected segments. The lung re-expanded adequately and no collapse of the chest wall was thought to be necessary. The hemithorax was closed in the usual manner and anterior and posterior drainage tubes were inserted.

Histopathological diagnosis: Tuberculosis.

Postoperative Course.—The upper drainage tube bubbled less than twenty-four hours. The lower tube no longer bubbled air after thirty-six hours and there was no apparent drainage from either tube thereafter. On roentgen examination increasing opacity of the chest was observed and the breath sounds became markedly diminished. On the third postoperative day, July 23, it was thought that a coagulum existed within the chest with clotting in the tubes and further drainage was not likely. Therefore an ampule of Varidase was instilled into the lower tube which was clamped off. The upper tube was allowed to remain open. Four hours later there was 250 c.c. of drainage from the upper tube. The lower tube was then opened and 200 c.c. of bloody fluid drained into the bottle. Roentgen examination on the fourth postoperative day, one day following the instillation of the enzymes, showed only partial clearing but there was very marked improvement on physical examination (Fig. 7).

Breath sounds came through adequately at this time. The patient's temperature before the instillation of the SK-SD was 100.4° F. Within eight hours after injection her temperature rose to 103.2° F. and fell by lysis to 101° F. the next day and it became low grade within forty-eight hours. Because of no further drainage from the upper tube it was removed on the fourth postoperative day; one day following the instillation of the enzymes. On the fifth postoperative day there was only a minimal amount of additional drainage from the lower tube and it was removed. The patient's course thereafter was uneventful. The breath sounds continued to improve and her general condition improved comparably. She was discharged on July 31, eleven days following surgery.

A follow-up roentgenogram on the fifteenth postoperative day, August 4, 1951, disclosed marked clearing of the operated hemithorax (Fig. 8). Examinations at the County Hospital, and subsequently when the patient returned home on a modified bedrest program, indicated that continued improvement existed. Follow-up examination by roentgenogram showed increased clearing (Fig. 9). Sputums were negative on culture. The patient was last examined in March, 1952, and continued progress was evident.

Comment.—This patient exhibited a marked opacity of the operated chest with absent breath sounds throughout the operated area. The drainage was thought to be inadequate and because of the lack of breath sounds and the opacity in the operated chest seen by roentgen examination it was deemed evident that a coagulum had collected within the operated side. The immediate clearing as indicated by roentgenogram was not striking but subsequent roentgenograms showed very marked clearing and physical findings improved immediately following the use of the enzymes.

Patient E. C.—This 34-year-old white man was admitted to the hospital July 31, 1951. His history revealed that in November, 1943, while in the Armed Forces a chest roentgenogram revealed a small area of fibrosis in the right apex. This was believed to be of no clinical significance, and he was returned to full military duty. A follow-up roentgenogram in July, 1945, was considered negative. In April, 1949, a roentgenogram taken at a Veterans Hospital showed an infiltration in the right upper lobe. Sputums were negative for acid-fast bacilli and he was discharged with a diagnosis of arrested tuberculosis. A subsequent examination in July of 1950, revealed a possible cavity in the right apex with surrounding infiltration. Concentrates of sputum were negative for acid-fast bacilli. Repeat roentgenograms including tomographs in December, 1950, revealed a cavity in the right upper lobe. Tuberculin skin tests were positive in the second strength. An equivocally positive Coccidioidin test was present. In May, 1951, he was hospitalized at a Veterans Hospital and culture of the sputum for acid-fast bacilli was said to have been positive. This examination, however, was never confirmed. All other sputums on concentrates and by culture were negative for acid-fast bacilli.

Physical examination was essentially negative. Differential diagnosis resolved itself about coccidioidomycosis or pulmonary tuberculosis and pulmonary resection was advised.

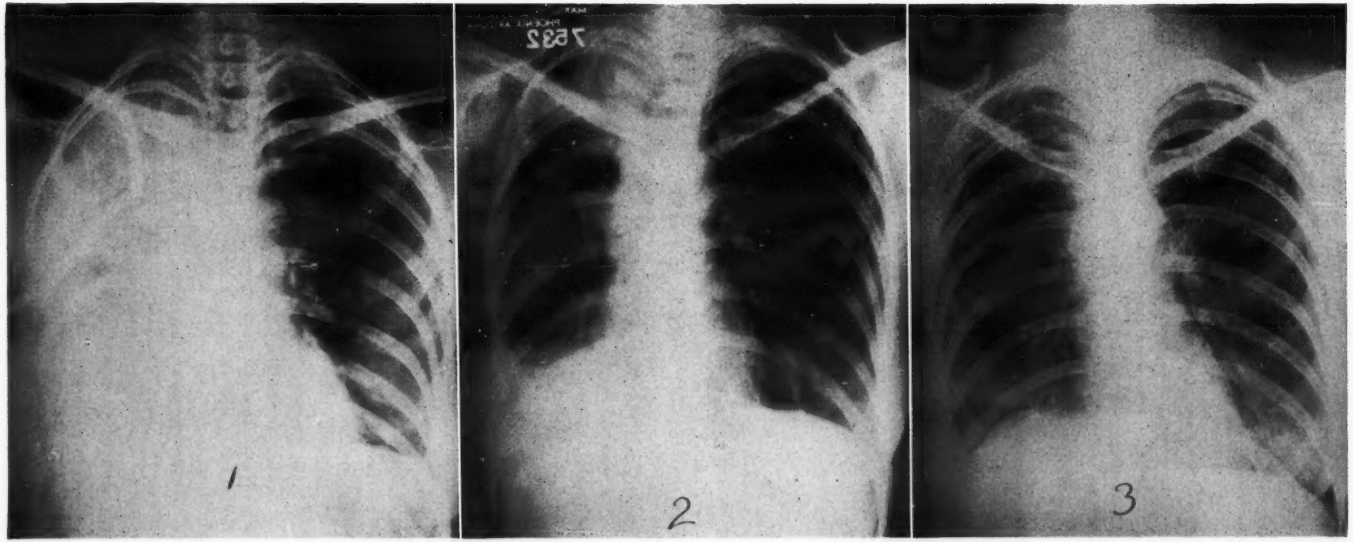

Fig. 7. Fig. 8. Fig. 9.

Fig. 7 (Patient Mrs. O. C.).—This posteroanterior roentgenogram of the chest was made the day after treatment with the enzymes (Varidase) which was carried out on the third postoperative day. Although there is marked clouding of the operated chest extreme improvement in the physical findings had occurred. A decortication was also performed in this instance and much of the density was therefore considered as pleural reaction.

Fig. 8 (Patient Mrs. O. C.).—A roentgenogram taken fifteen days after resection and only twelve days following SK-SD therapy. There is remarkable improvement over the previous x-ray and clinical progress was comparable in degree.

Fig. 9 (Patient Mrs. O. C.).—Follow-up roentgenogram of the chest made Nov. 4, 1951, approximately three months postoperatively. Further clearing is noted and the patient was clinically well.

Operation, August 22, 1951.—On entrance into the thorax, the right upper lobe was found to be about half its normal size. This was due to the marked reduction of the volume of the apical and posterior segments which were firm and airless. Due to the dense fibrous adhesions extrapleural dissection of the involved segments was required. Two firm rounded foci were palpable; one in the anterior segment of the upper lobe, and one in the superior segment of the lower lobe. These were enucleated during the procedure. The nodule in the superior segment was found to show evidence of central excavation but the nodule in the anterior segment of the upper lobe was solid and both contained amorphous caseous-like material. The cavity in the apical and posterior segments was inadvertently entered and showed granular pinkish-white walls. There was some collection of detritus covering the lining. The segments were removed in the usual manner and no major leaks followed the resection and the enucleation of the foci. The raw edges of the enucleated areas were approximated with interrupted sutures of fine silk. Before closure of the hemithorax anterior and posterior drainage tubes were inserted.

Histopathological diagnosis of the removed specimen was coccidioidal granulomata of the lung with cavitation.

Postoperative Course.—Preoperative laboratory studies indicated the patient's prothrombin time was slightly prolonged, to which too much significance was not attached because other tests, including bleeding and coagulation time, were normal. The prothrombin time was nineteen seconds and the control fifteen seconds. He received 70 mg. of vitamin K intramuscularly daily from August 15 to August 21.

Postoperatively there was slow bleeding into the chest cavity, necessitating a total of six transfusions. The drainage tubes by the second postoperative day failed to drain and a large opacity was seen in the upper lung field (Fig. 10). His hematocrit the first postoperative day was 41 and he received a pint of blood. The next day the hematocrit was 31 and he received five pints of blood. Because of the accumulated clot in the upper right hemithorax and the thought that bleeding might be due to a prolonged prothrombin time the thought of exploration was discarded and instead treatment with Varidase was decided upon. On the third, the fourth, and the sixth postoperative days ampules of Varidase were instilled into each of the drainage tubes. Each time the enzymes were allowed to remain in situ for four to six hours. On August 25, following an initial instillation, 700 c.c. of fluid drained within a twelve-hour period subsequent to the reopening of the tubes. A total of approximately 2000 c.c. of bloody fluid escaped into the drainage bottles from the use of the enzymes. Following each instillation there was a leakage of air for a short period of time. After all the accumulated fluid was drained the leakage usually stopped within about six hours. All leakage ceased following the last instillation. The drainage tubes were removed on the ninth postoperative day. Following removal of the tubes there was rapid and continued improvement by physical and x-ray examination (Figs. 11 and 12). The amount of air leaking into the pleural space while the tube was clamped off was not enough to cause embarrassment of respiration on the first two occasions but the third instillation on August 28 produced some dyspnea after six hours which was promptly relieved when the tubes were open and suction applied. He was discharged from the hospital and was seen three months later at which time no complicating factors were evident.

Comment.—In this particular instance it was thought that the bleeding was related to the prolonged prothrombin time. In a previous experience gained by the author following a sympathectomy at which blood loss was unusual in amounts, a prolonged prothrombin time was found to exist. Despite the presence of such a laboratory finding the enzymes were used in that particular instance without any cause for alarm. The enzymes had the desired effect and no evidence of continued bleeding was observed. Re-exploration is sometimes an unsatisfactory procedure where the postoperative bleeding is moderate and when performed the source of bleeding frequently cannot be discovered. With these thoughts in mind the treatment in this particular complication was thought best to be as conservative as possible. The enzymes (Varidase) were therefore used. It is to be noted that leakage of air was manifest following each instillation of the enzymes, which was probably the result of dissolution of

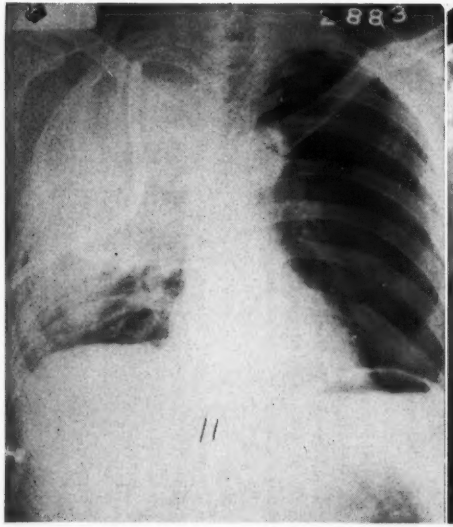

Fig. 10.

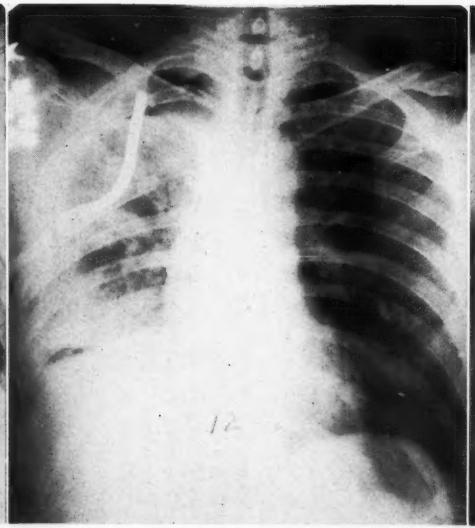

Fig. 11.

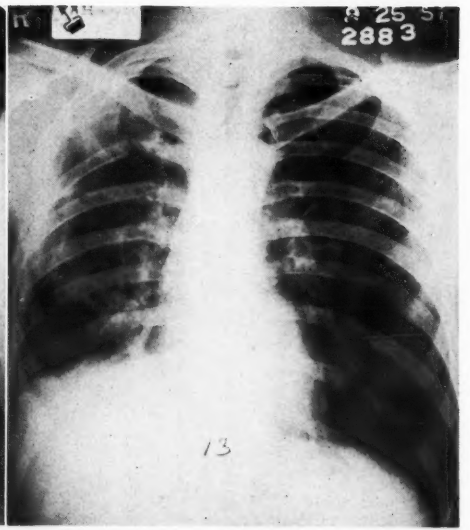

Fig. 12.

Fig. 10 (Patient E. C.).—Roentgenogram appearance of the chest on the second postoperative day depicting the large coagulum in the upper three-fourths of the right hemithorax. The tubes at this time were not functioning and the hematocrit had fallen indicating the likelihood of a blood clot in the operated side.

Fig. 11 (Patient E. C.).—The roentgenogram taken of the chest on the seventh postoperative day, following therapy on the third, fourth and sixth days and before the tubes were removed. There has been marked resolution of the density seen previously with drainage of a total of 2,000 c.c. of fluid.

Fig. 12 (Patient E. C.).—Posteroanterior roentgenogram taken approximately one month after enzyme treatment. Additional clearing is shown.

the fibrin covering the intersegmental surfaces, but with adequate suction and drainage re-expansion occurred promptly in each instance. After the last instillation complete re-expansion was apparent and the tubes were removed in the usual manner.

PATIENT MR. R. D.—This 18-year-old white man was admitted to the hospital August 1, 1951. His main complaint at that time was cough productive of mucopurulent sputum of several months' duration. In addition he had numerous psychosomatic disturbances and complaints related to various systems. However, all the latter were ruled as having no organic basis and his pulmonary trouble was worked out completely. He had had a cough for about two years but, during the year prior to his admission, he began to raise mucopurulent sputum and occasionally this was greenish or grayish brown. He denied any frank hemoptysis. Work-up at the hospital showed a positive tuberculin skin test (first strength) and a positive skin test (1:100) for coccidioidomycosis.

Physical examination was essentially negative except for the chest. A few rhonchi were heard on deep and forced respiration over the left lower lobe posteriorly and in the axillary region. The sedimentation rate was 31 (Westergren method). Sputum was negative for acid-fast bacilli on concentrate and by culture. A roentgenogram of the chest revealed a thin-walled cavity in the left lower lung field with minimal adjacent mottled infiltrates. This was considered to be a cavity due to coccidioidomycosis and from the history and observation it was thought to be infected.

Operation, Oct. 5, 1951.—On opening the thorax a few filmy and fibrous avascular adhesions were found over the fissure about the midaxillary region. Crossing the obliterated major fissure in its central portion there was a slightly indurated area measuring about 4 cm. in diameter which, by palpation, indicated an underlying cavity. This lesion was found to lie about half in each lobe along the fissure region. During enucleation of the cavity by blunt and sharp dissection from the lobes it was inadvertently entered and a small amount of grayish-tan detritus escaped into the wound. Later the cavity was further opened and used as a guide in dissection as one would do in dissecting out a hernia. Very little air leakage and bleeding occurred along the plane of dissection. No attempt was made to close the defect in either lobe. Following removal of the cavity reinflation of the lung was prompt and only minor air leaks occurred. Before closure a large fenestrated latex rubber tube was introduced through a subjacent rib space and a No. 20 French catheter was introduced through the second anterior interspace.

Histopathological diagnosis: Coccidioidomycosis (by culture).

Postoperative Course.—Following operation there was a gradual diminution of breath sounds over the base of the operated hemithorax. The breath sounds over the upper and anterior portions of the lung were good and on the fourth postoperative day the upper tube was removed but there was evidence of effusion at the base. On the sixth postoperative day mild subcutaneous emphysema was noted in the upper anterior chest and roentgenograms and fluoroscopy disclosed partial collapse of the lung and loculated areas of fluid (Fig. 13). A closed thoracotomy was performed at the second anterior interspace and in addition a thoracentesis was accomplished in the lower anterior hemithorax with removal of about 250 c.c. fluid and about 200 c.c. of air. Varidase was then injected into the lower tube which remained in situ. On manipulating the tube some of the fluid into which the enzymes had been mixed leaked onto the skin. It was then deduced that the lowermost fenestration in the indwelling drainage tube was near the skin surface. The tube was then fixed tightly within the chest by means of adhesive dressings. The tube remained clamped off for a period of six hours. The upper tube which had been inserted was allowed to remain connected to a water seal and suction. Six hours after the injection of enzymes on opening the tube about 150 c.c. of fluid drained into the bottle. Only minimal drainage occurred from the upper tube but air was stated to have escaped. The following day re-expansion was apparent and marked improvement had occurred clinically (Fig. 14). Tracheal suction was instituted and a moderate amount of thick tenacious brown secretions were obtained. The lower tube was removed on the following, the eighth postoperative, day. The upper catheter inserted at

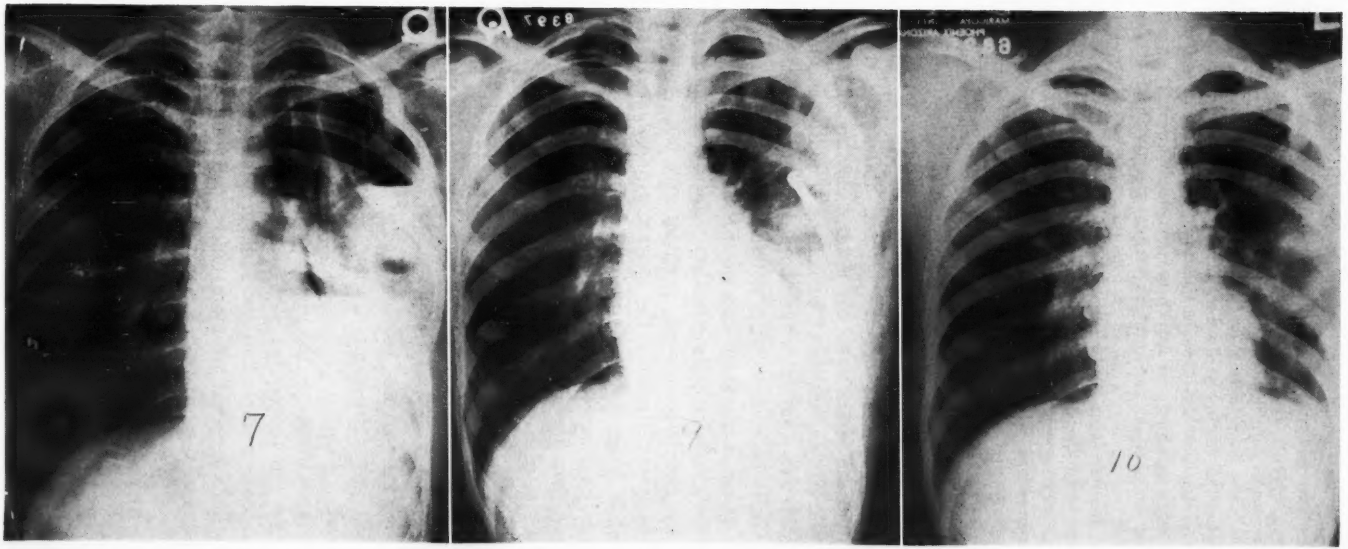

Fig. 13. Fig. 14. Fig. 15.

Fig. 13 (Patient R. D.).—Postoperative roentgenogram of the chest taken after discovery of tissue emphysema six days after enucleation of a coccidioidal cavity. Hydropneumothorax is well demonstrated.

Fig. 14 (Patient R. D.).—Roentgenographic appearance of the thorax the day after the instillation of the enzyme and closed thoracotomy. There is complete re-expansion of the lung.

Fig. 15 (Patient R. D.).—The roentgenogram of the chest made ten days after treatment with Varidase and seventeen days after thoracotomy. A satisfactory result has been obtained with only moderate reaction in the operated area remaining.

the time of closed thoracotomy was removed in three days. The patient showed marked improvement in aeration and clearing by roentgenogram. Subsequently, on the twelfth postoperative day, he was discharged for further convalescence at the County Hospital.

Comment.—Enzymes were used in this particular situation in order to dissolve the collected material in the base of the operated chest. It was thought that dissolution of the coagulum would enhance re-expansion which was mandatory. In this instance there was only minimal amount of drainage following the use of the enzyme but there was very prompt clearing both by physical examination and roentgen study. Despite the fact that a large lesion had been enucleated leaving bare surfaces in both the upper and lower lobes, fistulae did not form. It was reasoned that the pneumothorax, seen by roentgen examination, occurred through the improperly placed drainage tube and not through a spontaneous fistula in the operated site, for following the closed thoracotomy and the use of the enzymes, only small amounts of air leakage was evident. The patient was seen at subsequent follow-ups as late as March, 1952, and has shown continued improvement although a roentgenogram shows peculiar ringlike pleural markings about the operated area, thought to be of no significance as determined by a bronchographic study (Fig. 15).

DISCUSSION

After partial pulmonary resection the healing and restorative processes depend upon the obliteration of air leaks, the natural clotting of oozing surfaces and small vessels, prompt re-expansion of remaining lung tissue, and the elimination of air and exudative fluid from the thorax. Since SK-SD (Varidase). lyses fibrin, its use might be considered a detriment to these healing factors. However, the enzyme system apparently does not prolong bleeding from exposed surfaces or interfere with the clotting mechanism within the lumen of the small vessels as judged by the results in its early postoperative use.

With an adequate system draining the thorax, air leakage from raw surfaces, and the disposal of fluids usually is readily accomplished. Under certain circumstances, however, clotting or gel formation of the drainage occurs faster than it can be delivered from the chest and any damming back of further drainage hastens the formation of a space-occupying coagulum about the expanding lung.

Frequently on removal of a drainage tube, a fibrin plug is observed lying within its lumen which no doubt interferes with adequate dispersal of the leakage. By dissolving such a plug and with dissolution of the collection within the chest cavity, on using the enzymes, re-expansion of the lung can be facilitated. Following re-expansion any subsequent drainage is readily discharged before the tubes are removed.

At operation, in three instances, the pleural cavities were exposed to active tuberculous foci during the procedures, yet in no case was there evidence of the infection being seeded or spread in the lung or pleura after the enzymes were used. These patients received streptomycin but several had had the drug previously and no index of the organism's sensitivity was available at the time of their treatment.

In patient O. J., who was reoperated on the tenth day after resection, the results of the previous treatment with the enzymes were observed. In the area where the substances were effective the pleural surfaces were relatively smooth and pliable, although injected, and this region of lung expanded readily on reinflation. The operated surface was firmly fixed to the adhering diaphragm

and apparently the adhesions remained intact during treatment. There was no leakage from the thoracotomy incision when the enzymes were again instilled the day after the second operation and the wound healed per primam.

The use of the enzymes in patient E. C. was thought to have possibly circumvented a second operation for decortication. As judged by the amount of fluid obtained on treatment and the large density in the involved area on the roentgenogram a sizeable coagulum was present. Despite the prolonged prothrombin time and evidence of bleeding into the area, treatment with the enzymes brought about a favorable result. If the enzymes had adversely affected the clotting mechanisms at the bleeding source there seemingly would have been indications of increased hemorrhage and not termination of it as occurred.

It appears that clotting within the operated thorax and the formation of a fibrin plug in the lumen of the drainage tubes occur not infrequently. One cause for prompt clotting with resulting dysfunction of the drainage system may be attributed to the accelerated coagulation of blood produced by the use of antimicrobial agents.[14]

Since the healing processes are not patently slowed and there is no evidence of the enzymes affecting the underyling disease process it would appear that these preparations can be employed advantageously, early postoperatively after partial pulmonary resection.

SUMMARY

1. Six patients were treated with SK-SD(Varidase) early postoperatively, following partial pulmonary resection.

2. The procedures were performed singly or in combination and included lobectomy, segmental resection, decortication, and enucleation of disease foci.

3. The diseases encountered were tuberculosis (three cases), coccidioidomycosis (two cases), and bronchiectasis (one case).

4. The enzymes were instilled through drainage tubes already in situ on the second postoperative day (one case), the third postoperative day (two cases), the fourth day (one case), the sixth day (one case), and the eighth day (one case).

5. One patient was reoperated, after segmental resection had been performed ten days previously, and the enzymes were instilled the next day.

6. In no instance was there a chronic fistula created or evidence of deleterious effect on the underlying disease process.

7. All the wounds healed per primam and no leakage was manifest into or from the thoracotomy incisions.

8. The results were satisfactory clinically and favorable from a roentgenologic viewpoint.

ADDENDUM

Since the data for these cases were compiled, three additional cases in which the enzymes were used early postoperatively following pulmonary resection procedures have been treated successfully with similar favorable results:

1. A patient following decortication of the left lung and enucleation of multiple foci from the left upper lobe received the enzymes on about the tenth postoperative day.

2. A patient who had a right middle and right lower bilobectomy was treated on the fourth postoperative day.

3. A patient who underwent an exploratory thoracotomy with a preoperative diagnosis of carcinoma was found to have a granulomatous lesion in the right lung from which generous biopsy material was removed. This patient had an injection of the enzymes on the sixth postoperative day.

None of these patients had any deleterious effects in the use of the enzymes and a prompt and satisfactory postoperative recovery.

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DISCUSSION

DR. C. F. DANIELS, New York.—We are indebted to Dr. Read for his studies presented today and two years ago which have contributed much to the management of postresection hemothorax. If a small rent is made in the pericardium at the time of resection and is followed by hemothorax, the development of cardiac tamponade may follow the administration of streptokinase and streptodornase. Such a situation developed in a patient who had a middle and lower lobectomy, parietal pleurectomy, and partial decortication of the upper lobe for what was believed to be a mediastinal tumor eroding the intermediate bronchus and adherent to the pericardium. A small rent in the pericardium was left uncovered. Postoperatively, clotted hemothorax occurred. On the eleventh postoperative day intrapleural administration of streptokinase and streptodornase was followed by drainage of 900 c.c. of serosanguineous fluid. The next day it was evident that serious cardiac tamponade had occurred. Apparently with partial lysis of the clot occluding the small pericardial window, fluid flowed into the pericardium but a ball-valve mechanism prevented its egress. The emergency aspiration of 300 c.c. of serosanguineous fluid gave immediate relief of symptoms. Further intrapleural administration of the enzymes resulted in clearing of the hemothorax without recurrence of cardiac tamponade.

DR. MICHAEL DE BAKEY, Houston, Texas.—Dr. Read, I think, has provided convincing evidence of the value and safety of these agents in the immediate postoperative period under these circumstances where it is desirable to remove pleural effusions that accumulate and prevent prompt expansion of the lung and obliteration of the space. He referred to some experimental studies that we did about a year ago, with the purpose of determining whether or not there was any jeopardy to the healing process following pulmonary resection if these agents were used in the very early postoperative period. It was obvious from these studies that the healing process was not jeopardized if the pulmonary resection was properly performed and, on that basis, we used these agents clinically in six cases; three patients following pulmonary resection under circumstances similar to those described by Dr. Read, and in three cases of esophageal resection. In no instance was there jeopardous healing following their use, and the advantage which resulted from their use was similar to that described by Dr. Read. We believe, therefore, that our experimental as well as clinical observations can add confirmation to those which Dr. Read has presented.

DR. READ (Closing).—I want to thank the discussors, especially Dr. De Bakey. I was privileged to use his paper before it was published; he was kind enough to send me a copy for use in preparation of this manuscript.

I want to emhasize the very great importance of having tubes in situ when this material is used under the related circumstances. If this is not done you can almost guarantee that something catastrophic is going to occur. I would strongly advise also to have suction available, and also the possibility of even introducing another tube if it becomes necessary. There is one case which I was not able to report because of the time allotted. That is an incident, that will be included in the published manuscript, of a young man in whom I did a basal segmental resection of the left lower lobe. Postoperatively, drainage was very sluggish. I might add that I did not use an upper tube; in other words, it was only single tube drainage. During my training, several men impressed upon me the importance of using two tubes. However, in this instance only one tube was used. It seemed to be an easy situation and I thought that maybe the postoperative course might be hastened. Rather early in the postoperative course it was obvious that drainage was going to be difficult. Coagulation occurred, and the enzymes were instilled through the lower tube. However, they were instilled about the fifth day. Previously we reported that organization of coagulant can occur as early as the fifth day. There was a large pocket superiorly in this case and it was my assumption that the enzymes never permeated this large coagulant. There was evidence of results in the lower portion where the enzymes did reach and infuse about the coagulant. Additional aspiration superiorly yielded no fluid. We have emphasized the importance of obtaining fluid before one instills the enzyme material. None could be obtained in this instance, therefore enzymes were not instilled superiorly.

Subsequently, on about the tenth postoperative day, this man was reopened and a large coagulant and fibrinous gel overlying the entire lung had to be decorticated and removed. At that time we made an observation of the segmental resection and the effect of the treatment of the enzymes in this area. As we had strongly suspected but never observed previously, the remaining superior segment, which was quite large in this case, was quite smooth and pliable, the pleura was injected, and it was firmly adherent to the diaphragm along the segmental surface. It was pleasing to note that the area where the enzymes had been effective seemed to show a very good response to the treatment.

REHABILITATION IN THORACIC SURGERY

ALBERT HAAS, M.D., HOWARD A. RUSK, M.D., AND WALTER N. GOODMAN, R.P.T.
NEW YORK, N. Y.

TO DATE, relatively little attention has been given to the rehabilitative phase of the postoperative care of patients who have undergone thoracic surgery. The Veterans Administration has an active program in this vital field, but, generally, comprehensive programs do not exist. As a rule, tuberculosis sanatoria adhere to the old method of encouraging their postoperative cases to spend many hours lying supine on a supporting bolster, the objective being to "stretch the spine." Obviously, this procedure does nothing to combat the muscular atrophy and atony, the fibrous matting of the affected soft tissues, the contractures and the potential deforming scoliosis. On the contrary, it actually encourages all these undesirable pathologic changes frequently leading to progressively increasing lateral shifting and rotation of the spinal column and the ribs. The postoperative atrophy and dysfunction of the important muscles of the affected side are no match for the tonic muscles of the opposite unaffected side leading to imbalance of the muscular and ligamentous relationship with consequent distortion.

Starting with this basic concept of the residual postoperative pathology, our problem was to:

1. Find effective means of preventing atrophy of the affected muscles and lessen fibrosis and matting of the soft tissues of the involved side, since the resultant adhesions may seriously hinder restoration of function.

2. Anticipate and thus prevent compensatory contractures of the muscles of the unaffected side, thereby limiting the apparently inevitable scoliotic torsion of the unbalanced spine. Obviously, the ultimate, complete restoration to normal cannot always be attained, but much can be done to lessen the ultimate disability and functional handicap.

3. Combat fibrotic and arthritic changes in temporarily immobilized joints; a complication which, if ignored, may well result in permanent "freezing."

Naturally, the more extensive the operative procedure, the more severe is the pathologic residium, its anatomic distortion, and its physiologic malfunction. A "seven-rib" thoracoplasty resecting ribs, transverse processes, ligaments, muscles, etc., leaves profound anatomic and functional devastation. Not the least of the latter is the extent of damage to the nerve and blood supply of the sectioned muscles frequently irreversible. The more serious the nerve damage, the less satisfactory will be the rehabilitation of the affected muscles.

From the Department of Physical Medicine and Rehabilitation, New York University College of Medicine.
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Aside from the immediate sequellae of the surgical procedure, it is necessary to anticipate the potentially disabling effect of prolonged bed rest so essential in the treatment of the tuberculous patient. This is particularly noxious in cases wherein the patient assumes a comfortable but relatively distorting position while at rest. While this problem is primarily met with in the rehabilitative care of the tuberculous patient, the problem is similar in all post-thoracic surgical care regardless of the etiology.

Extensive surgical procedures require the division of:

1. The scalenus group of muscles which are detached from their insertion to the first and second ribs. These tendons are not reattached.

2. The corresponding parts of the trapezius, rhomboids, serratus magnus, latissimus dorsi, and the pectoralis minor, all of which are reapproximated and sutured.

Since in thoracic surgery, particularly in tuberculous cases, the operative procedures are customarily carried out in "stages," the resultant surgical trauma and all its sequellae require repetitious therapy two or three times in each case. No sooner do the sectioned muscles begin to heal than a new operative stage separates the sectioned tabs.

It should be reiterated that all sectioned muscles other than the scalenus group are reapproximated and sutured. The healing process progresses slowly. Therefore, during the early postoperative stage, rehabilitative exercises must be given with extreme caution and patience.

It should be emphasized that in thoracoplasties, the bony support of the sectioned muscles is gone, and the weakened muscles now constitute an integral part of the thoracic wall and must bear their share of the potential strain and stress. Therefore, one of the ultimate aims must be to strengthen these muscles to the very maximum of their potential.

Furthermore, the absence of the bracing ribs results in a positional shortening of the rhomboids, the trapezius, etc. Studies in the physiology of muscular activity have demonstrated that a muscle functions best when the contraction is initiated with the muscle in its normal resting length. Shortening, therefore, leads to inefficient function. In addition, atonicity of the muscles supporting the corresponding scapula, may, in some instances, lead to a "dropping" or a sagging of the scapula causing concomitant dysfunction and often irritation of the underlying area. The patient, in an effort to avoid the incidental discomfort, voluntarily "locks" the shoulder in an elevated position generally referred to as "high shoulder" with its compensatory "high pelvis" on the same side. This malposition often leads to contracture of the trapezius and limitation of function of the shoulder girdle. It is not unusal for the surgeon to attempt to solve this problem by removing part of the irritating lower rib or with a partial scapulectomy. Adequate therapeutic exercises can usually prevent this "dropping" of the scapula, obviating such secondary surgical procedures. As noted previously, another complication of thoracic surgery is the fibrosis and ankylo-

sis of the corresponding shoulder girdle. In an effort to lessen postoperative pain and discomfort, the patient deliberately splints the involved area by holding the arm and shoulder girdle rigidly at the side. Unless this is anticipated and prevented by proper posturing and active and passive exercise, permanent severe "freezing" of the shoulder is almost certain to follow.

Fig. 1.

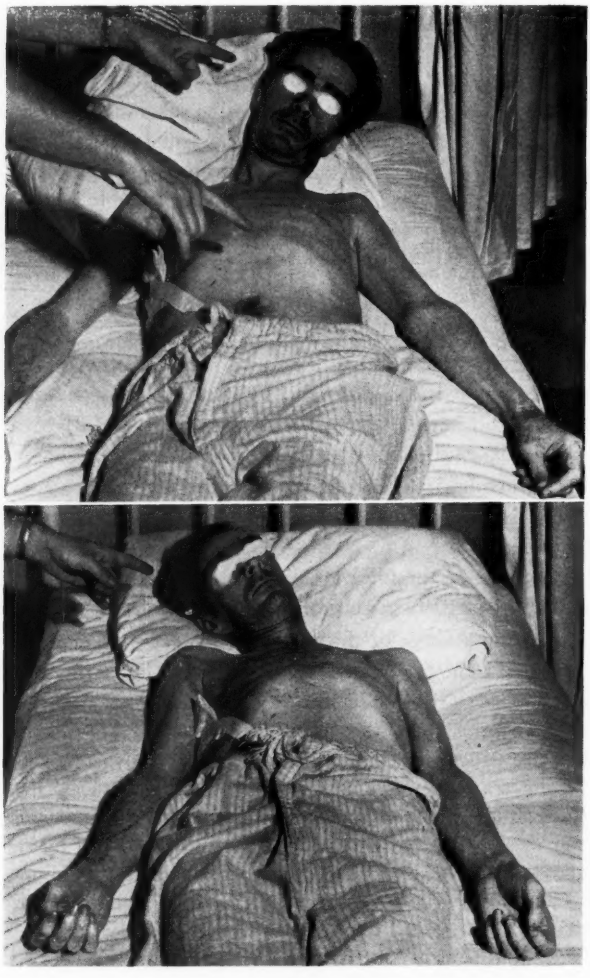

Fig. 2.

Fig. 1.—Poor position postoperatively (five days); (*a*) head to unaffected side; (*b*) hip to unaffected side; (*c*) too many pillows (under shoulders); (*d*) buttock weight not evenly distributed.

Fig. 2.—Exercise 1.

At Bellevue Hospital during the past eighteen months, a comprehensive rehabilitation program for the postoperative tuberculosis patient has been carried out as a cooperative program of the Chest Service and the Department of Physical Medicine and Rehabilitation to effect a physiologically sound means of com-

Fig. 3.

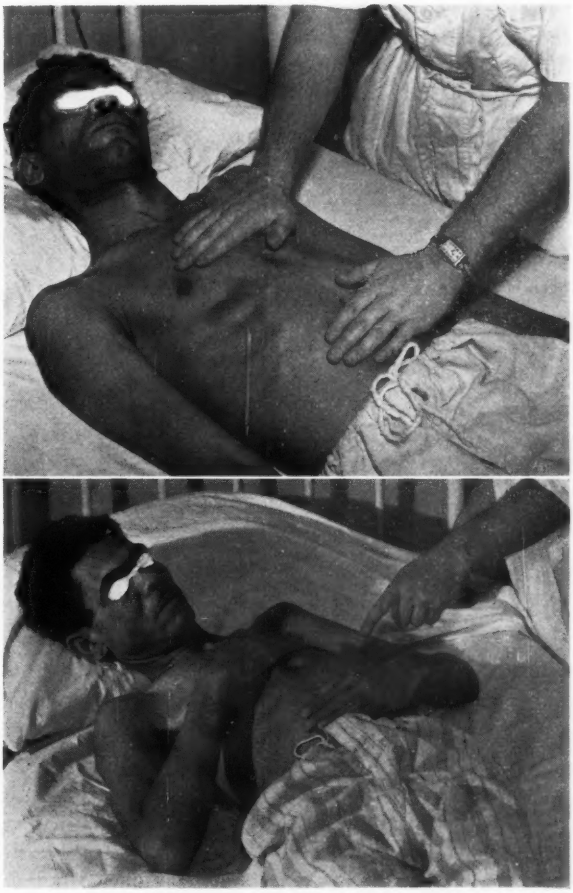

Fig. 4.

Fig. 3.—Exercise 2.
Fig. 4.—Exercise 3.

bating residual disabilities. Since all patients were seriously ill with tuberculosis, the intensity and frequency of the therapeutic efforts had to be carried out with extreme caution.

The corrective therapy program has been divided into two distinct phases: the pre- and postoperative. The objective of the former is to "educate" and

strengthen the synergistic muscles not directly affected by the operative procedure, so that they may take over, in so far as possible, the functions of the primary muscles which are temporarily disabled. Further, the patient is carefully trained in the techniques of diaphragmatic breathing, which is essential in the postoperative stage. This is combined with emphasis on proper posture—lying, sitting, and standing. Finally, the patient is taught the basic exercises which he will require postoperatively preoperatively. This program is initiated twice daily ten days before the scheduled operation is carried out. Teaching is greatly simplified by the use of mirrors. Within twenty-four hours after the operation, the second phase is started and is carried on until maximum possible rehabilitation is attained, which may be a matter of weeks or many months.

Fig. 5.

Fig. 6.

Fig. 5.—Exercise 4.
Fig. 6.—Exercise 5.

Corrective exercises are customarily divided into: (a) passive—where the entire movement is carried out by the therapist; (b) assistive (active assistive) —wherein the patient does as much as he is capable of, and the therapist completes the indicated ranges of motion; (c) active—wherein all the motion is carried out by the patient himself; (d) active-resistive—wherein "load" is added to the exercises in order to increase the power of the muscles.

The routine of exercises used in post-chest surgery is as follows:

PREOPERATIVE STAGE

Position: lying. Bed mirror tilted over patient.

EXERCISE 1.—Emphasize correct bed posture. (a) *Level pelvis*—avoiding any rotation or "lifting" of one hip. (b) *Level shoulders*—which are held parallel to the level hips. The shoulders must be in normal relaxed position and not be elevated. (c) The head, in cases of impending thoracoplasties, is held in position of lateral bending to the operative side. In thoracic surgery other than thoracoplasties, where the scaleni muscles are not severed, the head is held in normal position, at a right angle to the trunk.

Fig. 7.—Exercise 6

EXERCISE 2.—Pelvis and shoulders level, head normal. Patient places left hand on chest, right on abdomen. He is instructed to breathe abdominally (diaphragmatically), the right hand moving with each inspiration and expiration. Patient is taught not to move the chest or the left hand, thus striving to avoid as far as is possible thoracic breathing.

EXERCISE 3.—Position—supine. Patient bends trunk laterally toward nonoperative side. He is instructed to breathe diaphragmatically with the "operative" side only. Postoperatively this exercise is most important in the hastening of mobilization of the affected side of the diaphragm and thus help avoid paradoxical breathing in thoracoplasties and speeding pulmonary re-expansion in excisional operations. Incidentally, this exercise induces the cough reflex, which is of considerable importance in evacuating the pathologic contents of the bronchi.

EXERCISE 4.—Active head extension; position—supine. Pelvis, shoulders and head held level. With chin depressed, patient presses head and neck backward for count of two. Relax for count of three. Repeat sequence three times. Objective to strengthen the primary and synergistic extensors of the head and the cervical spine (upper fibers of trapezius, splenius, longus colli, etc.).

EXERCISE 5.—Active shift of head to operative side: basic supine position. Head is moved laterally (like a Bali dancer) only to one side. The head, held at right angles to the body, is slid to the operative side for a count of two; returned to normal position for a count of three. Repeat alterations three times. *Object:* since (in thoracoplasties) the scalenus group will be permanently sectioned, the corresponding group (of the unoperated side) will tend to form

Fig. 8.

Fig. 9

Fig. 8.—Exercise 7.
Fig. 9.—Exercise 8.

contractures, deviating and rotating the upper spine. By stretching these muscles and also by strengthening the synergists of the affected scaleni, these potential deformities are anticipated and may usually be greatly limited.

EXERCISE 6.—Active adduction and depression of scapula (unilateral); patient supine. Therapist places his hand under the scapula. Patient is now instructed to press backward medially and downward on the supporting hand.

Object: to teach the patient the specific coordinative exercise that will be required postoperatively to restore the function of the adductors and depressors of the affected scapula (rhomboids, mid and lower fibers of trapezius, latissimus dorsi, etc.). This exercise incidentally stretches the pectoralis muscles, combating tendency to forward rotation of the shoulder. Repeat three times holding for count of three; rest periods of three seconds between exercises.

EXERCISE 7.—Active assistive depression of "affected" shoulder girdle. *Position:* supine. Forearm is flexed on upper arm, fingers on shoulder. Arm held at side of trunk. Therapist "fixes" shoulder girdle and flexed elbow joint with his fingers. Patient depresses the flexed arm downward, stretching the shoulder capsule, ligaments, and muscles. Hold for count of two. Relax, to normal position (do not raise shoulder above normal level) for count of three. Repeat three times. *Object:* to stretch and strengthen the muscles of the shoulder girdle (lattisimus, lower fibers of trapezius, pectoralis, etc.) and thus try to prevent postoperative "high shoulder." *This completes the preoperative procedures.*

POSTOPERATIVE ROUTINE

Start with the seven basic exercises given preoperatively. Follow the same sequence, timing, and alternation. Continue:

EXERCISE 8.—Abduction of the arm at shoulder. The procedure is active-assistive and unilateral. *Position:* supine, arm of operated side is flexed at elbow and held close to chest. Therapist supports arm at flexed elbow and at hand. Patient is encouraged to abduct the arm without strain, the therapist assisting the active effort. The exercise is repeated three times with intervals of rest of three seconds. *Objective:* to assure maximum possible abduction of the shoulder joint by preventing "freezing" and muscular atrophy.

EXERCISE 9.—Active assistive rotation of the shoulder joint. *Position:* supine, arm in same starting position as for Exercise 8. Therapist swings arm to maximum abduction (as in Exercise 8); then the arm is rotated at first externally then internally. Again the patient is encouraged to carry out this exercise to the point of tolerance, the therapist supplying the degree of assistance indicated. Repeat three times with periods of rest. *Objective:* same as with abduction, to assure maximum mobilization of the joint and hasten rehabilitation of the muscles of the shoulder.

EXERCISE 10.—Active assistive "horizontal" abduction and adduction of arm (unilateral). *Position:* supine, arm flexed at elbow and abducted to 90 degrees if possible; if not, as close as is possible. The therapist supports the flexed arm the same as in the previous exercises 8 and 9. *Object:* (a) to stretch the postoperative adhesions, and (b) to exercise the adductors of the scapula and the extensors of the arm during the abduction phase of this procedure. Frequency and time intervals are the same as in the previous exercises. The flexed arm is carried medially, striving to touch the opposite shoulder with the fingers.

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 10.—Exercise 9, *A*.
Fig. 11.—Exercise 9, *B*.
Fig. 12.—Exercise 10.

EXERCISE 11.—Active assistive elevation (flexion) of both arms. *Position:* supine. Patient clasps hands with arms extended and resting on trunk. He is instructed to elevate the arms slowly overhead to the point of tolerance, which may be quite limited in the early postoperative stages by the pain. *Objective:* mobilization of the shoulder joint and exercise of the muscles of the shoulder girdle and arm. Repeat three times with customary rest periods.

Fig. 13.—Exercise 11.

Throughout these exercises, it is essential to be on guard for substitution movements, i.e., elevation of the scapula, forward rotation of the shoulder, etc. It is desirable to adhere to physiologically normal joint movements.

The postoperative routine is diligently carried out in the lying position for a period of one week. At this time, if the condition of the patient permits, he is seated in front of a full-length posture mirror and the rehabilitative routine is continued as follows:

EXERCISE 12.—Active unilateral flexion of head. *Position:* sitting, with pelvis, shoulders, and head level. Patient bends the head to the "affected" side,

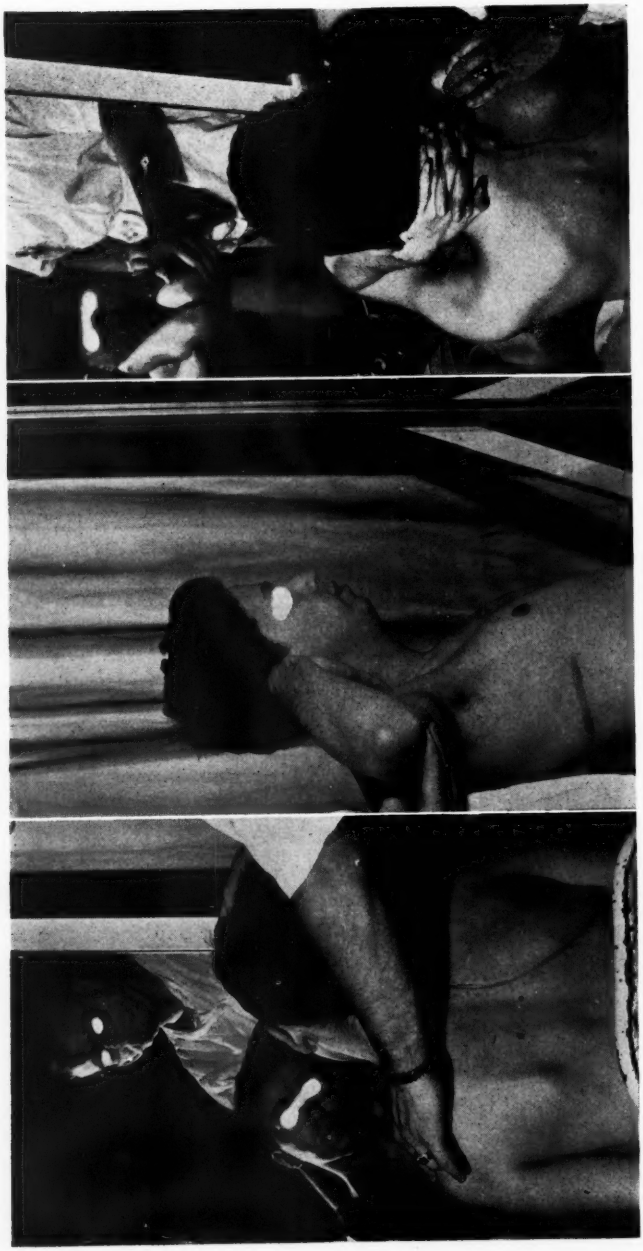

Fig. 14. Fig. 15. Fig. 16.

Fig. 14.—Exercise 12.
Fig. 15.—Exercise 13.
Fig. 16.—Exercise 14.

Fig. 17. Fig. 18. Fig. 19.

Fig. 17.—Exercise 15.
Fig. 18.—Exercise 16.
Fig. 19.—Exercise 17.

aiming to touch the ear to the shoulder. Avoid rotation of head. Hold for count of two. Return to normal position. Rest for count of three. Repeat alternations three times. *Objective:* to strengthen the residual flexors of the affected side and stretch those of the symmetrical (unoperated) side.

EXERCISE 13.—Active circumduction of both shoulders. *Position:* sitting, with arms flexed at elbows and held at sides of body, finger tips at shoulders. Patient carries flexed arms forward upward to right angles with the trunk; then the arms are abducted horizontally winging out to the sides of the body. Return to starting position. Repeat alternations three times with essential rest periods. *Objective:* to keep the shoulder joints freely mobile and to stretch the matted soft tissues. If patient finds this exercise too taxing, limit the procedure to the affected shoulder only.

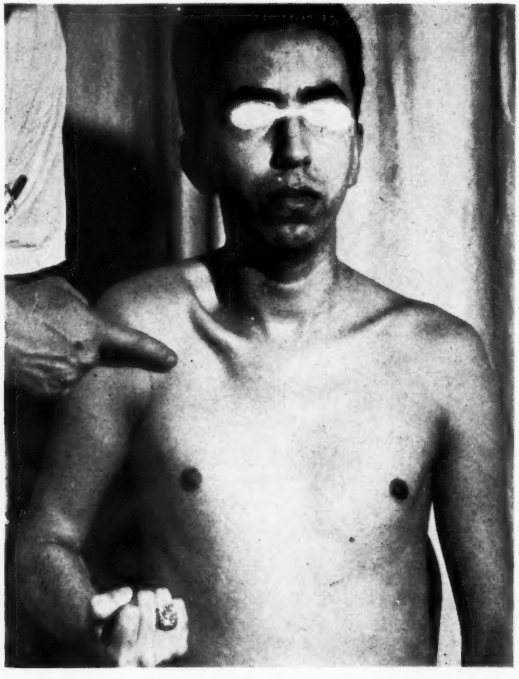

Fig. 20.—Exercise 18.

EXERCISE 14.—Abduction and adduction of flexed arms. *Starting position:* hands clapsed back of neck, flexed arms winged at sides, shoulder high. Patient adducts flexed arms touching elbows at front of body, then carries arms horizontally back to original position. Repeat alternations three times with usual intervals of rest. *Objective:* to stretch the postoperative matted soft tissues and exercise, primarily, the adductors of the scapula.

EXERCISE 15.—Adduction and depression of scapula. *Basic position:* hands clasped over umbilicus, arms held at sides, and shoulders depressed. Patient is

instructed to approximate the scapulae by contracting the adductor muscles. Repeat three times, with rest intervals. *Objective:* to strengthen the adductors of the scapula and stretch the pectorals.

EXERCISE 16.—Flexion and extension of the trunk. *Starting position:* sitting erect, arms hanging loosely at sides, knees together. Patient slowly lowers trunk until head touches knees and hands reach floor. *Objective:* mobilization of the spine and further stretching of the matted tissues.

Fig. 21.—Patients doing group exercises, which follow the basic routine as described. All patients shown had seven-rib thoracoplasties.

EXERCISE 17.—Same as Exercise 11 (see above), but carried out from the basic sitting position.

EXERCISE 18.—Because of the relatively strenuous nature of this procedure, it should not be utilized until the patient has regained maximum strength and vitality. With the patient in sitting position, forearm at right angles to upper arm and supinated, the patient carries the flexed arm posteriorly while the therapist applies resistance against the elbow. Return to starting position; repeat three times with rest periods. *Objective:* to develop the pectoralis minor to actual hypertrophy in an effort to fill in the postoperative cavitation of the upper part of the anterior aspect of the chest wall.

COMMENT

During the past eighteen months, we have observed the effect of a carefully planned rehabilitative program in preventing the apparently inevitable deforming sequellae in 287 patients undergoing surgery. There is a prevalent opinion

Fig. 22.

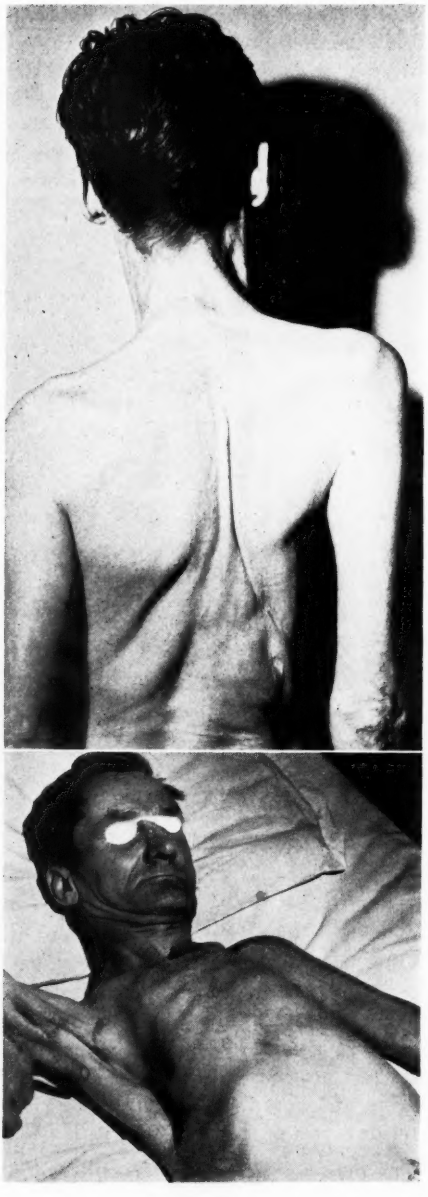

Fig. 23.

Fig. 22.—Case W. H. Classical scoliosis resulting from thoracoplasty in patient who did not receive rehabilitative measures. Patient had (1) ten-rib thoracoplasty, (2) pneumonectomy, and (3) pectoral myoplasty (for bronchopleural fistula).

Fig. 23.—Case W. H. Range of motion obtained in same patient after pectoral myoplasty when first rehabilitative measures were instituted.

Fig. 24.—Use of bed pulley for stretching after pectoral myoplasty which closed a bronchopleural fistula.

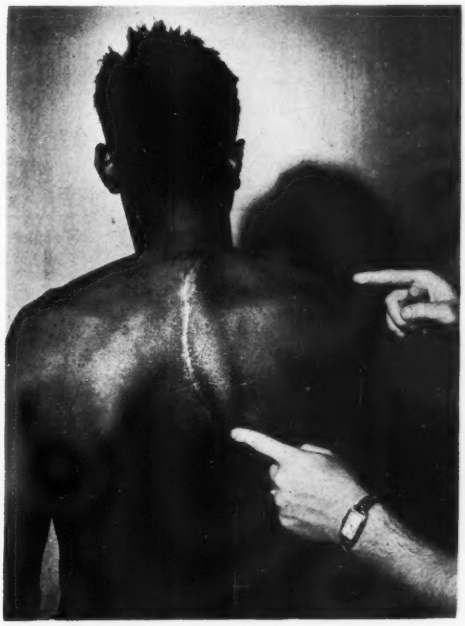

Fig. 25.—Typical high shoulder due to "riding" of angle of scapula on the eighth rib. Cervical scoliosis also results from the mechanical interference.

Fig. 26.

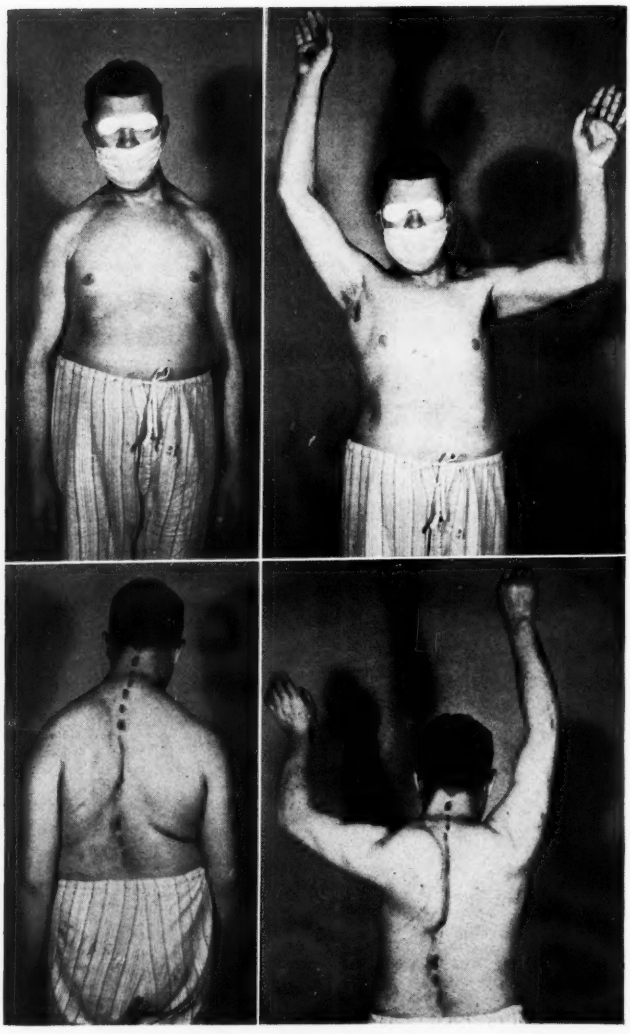

Fig. 27.

Figs. 26 and 27.—Case T. M. Patient received no therapeutic exercises. He had a seven-rib thoracoplasty in 1939.

that scoliotic deformity does not, as a rule, develop until many months after the operation. In our experience, the evidence suggests that this deformity often begins immediately after thoracoplasty. The more extensive the latter, the more rapid is the onset of the scoliosis. The remedial results obtained in 107 thoracoplasties and 180 "excisional" operations (with or without incidental limited thoracoplasties) were encouraging to the degree of justification of the effort and its continuation. It is recognized that the most conscientious and intensive rehabilitative routine may not always prevent the scoliosis. How-

Fig. 28. Fig. 29.

Figs. 28 and 29.—Case V. O. Patient who received pre- and postoperative exercises with a seven-rib thoracoplasty. These pictures were made one year postoperatively.

ever, by evaluation of twenty-seven nontreated compared to the treated series, considerably more showed thoracic deformity (particularly in thoracoplasties); there was limitation of range of motion of the corresponding shoulder (in some cases to the point of severe ankylosis); there was also not infrequent shifting of the mediastinal contents with resultant disturbance of cardiorespiratory function; and, finally, more pain and discomfort due to extensive arthritis and fibrotic changes in the non-treated group. Experience has shown the rehabilitative routine must be carried out over a period of many weeks, months, and, occasionally, for years. Patient education is paramount—not only the technique

but the importance of taking the exercises with planned regularity. To aid in this education program, a booklet illustrating and describing the exercises has recently been prepared for patients.

SUMMARY

1. During the past eighteen months, at Bellevue Hospital a carefully planned routine for rehabilitative care of postthoracic surgery cases has been in operation.

2. The results obtained by means of diligent corrective exercises have prevented, to a varying degree, scoliosis, "freezing," of the shoulder, matting, and atrophy.

3. Comparative study of nonrehabilitated cases emphasizes the advantage of these preventive and remedial measures.

4. Postoperative rehabilitation is an integral part of the total care of the patients who undergo thoracic surgery.

Photographs were taken by Mr. Stanley Simmons, photographer for the Department of Physical Medicine and Rehabilitation, New York University College of Medicine.

A RACK FOR UNDERWATER DRAINAGE BOTTLES

JOHN D. STEELE, M.D.
MILWAUKEE, WIS.

A SIMPLE, inexpensive rack for underwater drainage bottles is presented. This rack has the following advantages: the bottles cannot be tipped over, the fluid levels in the bottles and glass tubing are visualized easily because of the light behind the bottles, and the rack can be attached to a standard hospital bed temporarily (by means of hooks which fit over the bed springs).

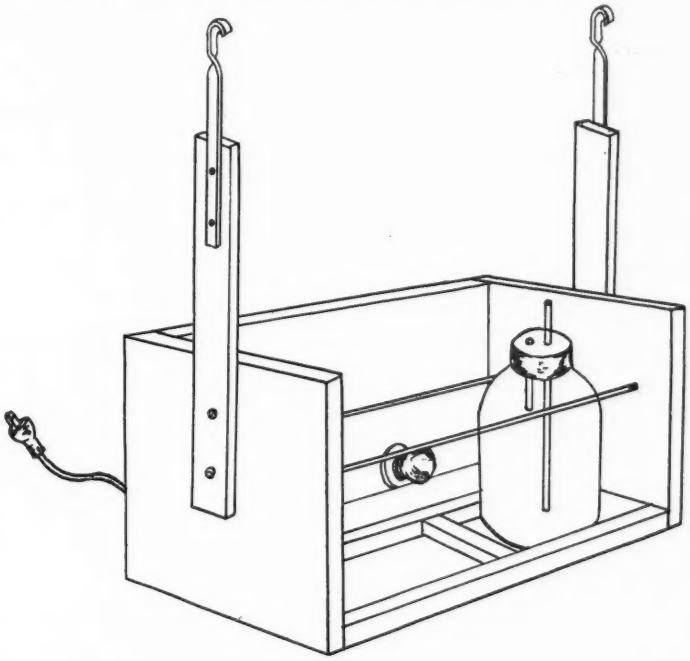

Fig. 1.

This rack can be constructed entirely of wood. However, the use of metal cross rods permits slightly better visualization of the fluid levels in the glass tubing. The 7½ watt lamp also serves as a convenient night light. The back of the rack, above the lamp, provides a space for printed instructions to hospital attendants regarding care of the bottles.

In some types of hospital beds (usually inexpensive ones) there is sufficient clearance between the bed springs and the cross rods of the bed to attach the rack to wooden cross pieces which are clamped to the rods. This eliminates the necessity of unhooking the rack from the bed (when the springs are elevated) and allows the bed to be moved at any time without disturbing the bottles.

From the Department of Surgery, Marquette University School of Medicine.
Received for publication April 7, 1952.

Announcement

THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

Notice of Annual Meeting

The 33rd annual meeting of the American Association for Thoracic Surgery will be held March 27, 28, and 30, 1953, in San Francisco, Calif. Headquarters will be at the Hotel Fairmont. Suitable accommodations also have been reserved at near-by hotels, the Mark Hopkins, the Huntington and the Sir Francis Drake.

Requests for Hotel Reservations

These should be mailed to Dr. H. Brodie Stephens, Chairman of Hotel Committee, American Association for Thoracic Surgery, Room 200, 61 Grove St., San Francisco 2, Calif. The following information must be included: (1) two choices of hotels; (2) type of accommodation desired—single, double, twin, room or suite; (3) name of other room occupants, if any, whether wife or another doctor; (4) date and approximate hour of arrival; (5) date of departure; (6) return address.

Abstracts for Papers

Abstracts for the presentation of papers at the 1953 meeting must be received on or before Dec. 1, 1952, otherwise they will not be considered by the Program Committee. *Five, repeat, five* copies of each abstract should be sent to the Secretary of the Association, Dr. Paul C. Samson, 2938 McClure St., Oakland 9, Calif. They should not be sent to the Editor.

The abstracts should contain from 200 to 250 words, and should accurately reflect the contents of the completed paper.

Applications for Membership

Completed membership applications must reach Dr. Edward M. Kent, Chairman of the Membership Committee, 1107 Clark Bldg., Pittsburgh 22, Pa., on or before Dec. 1, 1952, in order to be acted upon at the annual meeting in San Francisco.

All correspondence regarding membership, including requests for membership applications, should be addressed to Dr. Kent.